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TABLE OF LEADING ARTICLES.

Small Producer Gas Plants........................ 387
The National Hydraulic Interests.................. 387
The Congestion of the Elevated Railway Loop in Chicago 388
Coal Selection for Power Plants.................. 389
The Market Street Subway, Philadelphia. (Illustrated) 390
The Garbage Reduction Process at Toledo.......... 392
Lining a Tunnel with Concrete. (Illustrated)...... 393
Economy Tests of a 7,500-Kw. Westinghouse-Parsons Turbine. (Illustrated). 394
Concrete Work at Charles River Locks............ 395
The President's Message on Hydraulic Engineering Works 396
Temporary Elevators for the Erection of the Singer Building Tower. (Illustrated). 397
Single-Phase Electric Motive Power on the Rochester Division of the Erie Railroad. (Illustrated)...... 399
The New Plaster Mill of the American Gypsum Co. (Illustrated). 405
The Pitcairn Yard of the Pennsylvania Railroad. (Illustrated). 406
The Nelson St. Viaduct at Atlanta, Ga. (Illustrated) 409
The Detroit River Tunnel Caissons. (Illustrated)... 410
A By-Product Charcoal Iron Plant at Marquette, Mich. (Illustrated). 410
The Panama Canal Relief Map at the Jamestown Exposition. (Illustrated). 412
A Bad Case of Rusty Steelwork. (Illustrated)...... 413
Book Notes 413
Lattice Bars........................ 414
An Undermined Dam. (Illustrated)................ 414
Wire Rope for Concrete Reinforcement............ 414
Cost of Riveting........................ 414

Small Producer Gas Plants.

It is only recently that producer gas as a source of power has obtained a firm foothold in this country. Even now, with a considerable amount of effort on the part of the manufacturers, comparatively slow headway is being made. Big gas engines are coming to be fairly well known, but the logical step of feeding them from cheap producer gas is rather seldom taken as yet. The philosophy of the matter is very simple. It costs heavily to produce gas of high thermal value and particularly of high luminous value. On the other hand, low-grade gas, from the mere fact that it is of small calorific value, has per unit of energy a heavy distribution charge against it if furnished by a supply company. Hence fuel gas of a thermal value such as to give minimum cost per heat unit has not become at all a familiar thing, and the ordinary man, when invited to make gas of 100 to 150 B. t. u., gets suspicious and sheers off. Yet the practical question in gas production for power purposes is not how to make a gas of maximum thermal value, but of maximum thermal value for the money, which is a very different thing. It has been shown over and over again that coal can be used to make gas for an engine much more efficiently than it can be used under a boiler, and it is pertinent to inquire why it is not more frequently thus utilized.

Probably the chief reason lies in human inertia which resists attempts to force the mind out of the line in which it has been traveling. A secondary one of considerable importance is fear of the apparent complication which the mind associates with gas making. Now, in point of fact, it is really simpler to make gas in a modern producer than to make steam under the pressure necessary for a steam engine. The producer has been made nearly automatic in its action and can certainly be run successfully by anyone who has ability enough to run an ordinary domestic furnace, when once he learns the trick. Whether a comparatively inexperienced man can operate it in such wise as to reach the best economy is another matter. The simpler producers are fairly fool-proof as regards producing gas, but it is more than likely that inability to produce good and uniform gas in unskilled hands has been one of the obstacles in the way of working the apparatus at its proper economy. Several makers are willing to guarantee the production of a brake-horse-power-hour on the consumption of 1 to 1.25 lb. of coal in the producer, and this even in units as small as 50 h.-p. How nearly these figures can be regularly reached with ordinary labor and with output rigorously measured is an open question, but there seems to be no doubt that under favorable conditions the guarantee can be made good. It must be remembered that the engine in such plants involves extra expenditure on account of having to utilize a large volume of lean gas, and that the depreciation of the producer is a somewhat uncertain quantity. Here again it is likely that the system may suffer on account of its claims to automatism. All in all, however, producer gas can be made a very cheap and convenient source of power, particularly on a moderate scale, and considerable further progress is likely. The system seems certain to find more and more applications every year.

The National Hydraulic Interests.

The statements made by President Roosevelt at Memphis on Oct. 4 deserve more thoughtful consideration than they seem to have received. Those portions of them reprinted elsewhere in this issue form a most comprehensive outline of the important and varied relations of the various national hydraulic interests. The development of navigation on inland water-ways has frequently been discussed in state papers but there has always been a tendency to consider that the subject ended there. It is true that in the West the value of water for irrigation has been recognized and during recent years our chief magistrates have dwelt from time to time on this subject. President Roosevelt seems to be the first, however, to recognize the intimate relations which all branches of hydraulic engineering bear to each other and to the national welfare. In fact, few engineers have probably stopped to consider the closeness of these relations, and anyone termed a hydraulic engineer in this country was generally considered, even among his associates, to confine his attentions to power developments. This narrow view is unlike that which prevails in Germany, for instance, where a recognition of the many directions in which water is employed has given to the term of hydraulic engineer a far wider significance than it has on this side of the Atlantic. It is particularly gratifying to notice that this comprehensive understanding of the importance of our national water resources was emphasized by the President at a gathering primarily called for the purpose of discussing only the improvement of internal navigation. The President did well to point out clearly that while navigation is important there are many other uses to which rivers and lakes are put, and anything which is done for one interest must be executed in a spirit of fairness to all other interests which are likely to be affected by it.

A great deal has been printed recently concerning some statements by Mr. James J. Hill, who has taken a decidedly pessimistic view of the ability of railways to keep pace with the demands for transportation which the development of the country will produce. It is probable that some of these statements by the eminent railway builder and operator are to be taken with a large grain of salt, but it is nevertheless noteworthy that a number of men engaged in the higher walks of railway affairs look with favor upon the improvement of internal water-ways. The congestion of tracks by bulk freight paying low rates and interfering with the operation of trains from which a much larger revenue can be obtained has been altogether too frequently observed in too many sections of the country during recent years. It is unquestionably true that there is no problem to-day which is full of greater complications, of more factors of debatable importance, than railway transportation, and when it is still further complicated by considerations of competing water transportation, the problem is one which may well stagger a master intellect. Yet it is one which must be faced and solved, and the fact that our President has so fully recognized its importance as to approve a special gathering for its consideration is a gratifying indication that he, at least, appreciates its many aspects and proposes to be guided in his recommendations concerning it by the advice of specialists who have first conferred together regarding the scope of each aspect of the problem and the relations of the various factors. The interests which are affected are so important and diverse that any other method of seeking the truth is certain to produce results based upon an imperfect, disjointed appreciation of the whole vast problem.

This is well indicated by the attempt to force the national government into undertaking prematurely the construction of a deep water-way from the Great Lakes to the Mississippi River by way of the Illinois River. The arguments so far advanced for such a water-way are partly good and partly bad, and are manifestly based on incomplete data. The Engineering Record cannot reconcile the enormous expenditure for constructing a ship canal from the Great Lakes to the Mississippi and then canalizing that stream to the Gulf for sea-going vessels, with any economical results which now seem likely to follow from the completion of a water-way of such magnitude. The effect of the diversion of an enormous amount of water from the Great Lakes to feed the upper portion of such a canal is a subject so vitally important to the existing lake commerce of the United States, to say nothing of the

Dominion of Canada, that the suggestion seems impracticable of fulfillment. Moreover, there is always the latent distrust of all arguments of this sort in the nominal interest of navigation on account of the manifest desire of a part of the people of Chicago to have the nation construct an enormous ditch carrying so much water to the Mississippi that the sewage of the city can be turned into it forevermore. Nevertheless, the complications and simplifications which mark this interesting subject as it passes from one stage to another may ultimately give it an entirely different appearance from what it now presents, and it is certainly the part of wisdom to maintain a mind open to conviction on all these great problems until the commission which is now studying them is able to make a report of the comprehensive nature which is essential for the basis of any satisfactory study.

The statements made by President Roosevelt concerning the value of water for irrigation, water supply and other purposes, deserves far more attention than they are likely to receive. At the present time very few citizens of the United States, other than those who have lived abroad and become familiar with public works there, have any idea of the value of pure water. Even to-day in a good many of our large cities it is a pretty expensive article. It is bound to become far more expensive, as the filtration of the supplies becomes more generally practiced and it is necessary to go farther for them. For this reason some measure of national supervision over the quality of water is highly desirable, for most of our large streams are of an interstate character and the control of their flow and the purity of their water rests with the people of no one state. The United States Supreme Court has decided, in the recent suit of Kansas against Colorado, that the national government cannot intervene to protect such streams under any authority now given to it by the Constitution, but this does not mean that government supervision cannot be arranged by the mutual consent of States or by some other indirect method which Congress may devise. The same consideration makes the pollution of water supplies of an interstate nature a problem of much complexity, the importance of which is hardly recognized at the present time. The President also points out the great value of many of our streams from a power development standpoint, something that has just begun to receive the consideration it deserves. All these hydraulic and sanitary aspects of our internal water-ways must be considered along with those of navigation, and the President has done well to call the attention of the nation to this inter-relation and its deep signficance to the country as a whole.

The Congestion of the Elevated Railroad Loop in Chicago.

The downtown union terminal loop of the four elevated railroads in Chicago has become so completely congested that it is entirely impossible to operate any of these roads satisfactorily during the rush hours. This congestion has been serious for several years and has been growing worse apace with the natural increase in traffic due to the rapid growth in the population of the districts served by the four lines. The recent opening of several new branches of the latter, which tap very populous districts, has required numerous additional trains to be passed around the already overcrowded downtown loop, with the result that long, tedious delays to traffic are occasioned for at least an hour and a half each morning and night. Under the existing conditions it is generally conceded by engineers familiar with the circumstances that no appreciable relief can be afforded to this situation which so seriously affects daily such a large population. As might be expected, however, a great volume of suggested solutions of the difficulty have been variously promoted through the local daily press, rivaling, indeed, in number and range of feasibility the methods which have been proposed to enable the Manhattan terminal of the Brooklyn Bridge to handle the traffic that has overwhelmed it for years during rush hours.

Several principal conditions, which it is apparently practicable to change, combine to limit the capacity of the loop to about half that which should be available immediately, to say nothing of provisions for the future. First of all, the trackage of the loop is totally inadequate to handle the trains from all four of the lines tributary to it. In the second place, the short platforms at the stations on the loop limit the capacity of the latter probably as much as any one condition. The arrangement of the connections between the tracks on the loop and the different roads is a feature that adds another great limit to capacity for handling trains. The present separation of the traffic of all four lines, thus preventing any possibility of routing trains through from one road to another, also precludes an increase in capacity that might be obtained otherwise.

The two tracks on the loop are each a trifle over two miles in length, the loop being five city blocks one way by seven the other, so the total trackage is close to four miles. The inadequacy of this amount of trackage to provide proper terminal facilities for the four roads using it may be indicated by the fact that during a period of one hour each day over 150 five-car trains are scheduled to enter and leave the loop. Each of these trains is required to discharge and receive passengers at ten different stations in the two-mile circuit of the loop. The result is that at the most crucial periods of the day both tracks of the loop are filled with trains spaced a few feet apart, and long lines of trains are held up on each of the four roads waiting to obtain an entrance. The most feasible method of providing greater trackage facilities for this great number of trains is generally believed to be the removal of the south end of the loop several blocks from the present location, as it is impracticable to move the other sides. At the same time, the right-of-way in the city streets for such a change could scarcely be acquired without a considerable outlay for damages to the abutting property, although the district through which the extension would pass has actually been greatly retarded by the fact that it is outside of the present loop. Various other means of securing additional trackage have been suggested by engineers familiar with the circumstances, most of which changes contemplate the construction of tracks within the loop, but such extensions are completely forestalled by local conditions.

The two platforms at each station on the loop are just long enough to serve simultaneously two five-car trains on each of the two tracks. Careful investigations have shown that if these platforms could be lengthened so two six-car trains might be accommodated the capacity of the loop would be increased at least 10 per cent. When an attempt was made some time ago to carry out this improvement, however, the property owners adjacent to the stations secured a permanent injunction which prevents any such additions, so advantage cannot be taken of this means of relief.

The necessary arrangement of the connections between the different roads and the tracks on the loop causes each train of the two roads which use each loop track to cross the other loop track either in entering or in leaving. The entrance and exit for two of the roads are at the same corner of the loop, while the other two roads each enter and leave at separate corners. Consequently, when the trains of one road are entering or leaving the loop they not only interfere with the trains of the two roads on the other track, but also hold up the trains of the other road which uses the same loop track. The switches at these connections are equipped with the most perfect apparatus available and the operators handling them are unusually proficient in their manipulation, so no further improvement in the present arrangement can be expected at these points. The separation of grades where a train on one loop track is required to cross the other track at the corners of the loop has been suggested, but the practicability of obtaining a clearance of at least 14 ft. in 400 or 500 ft. by inclines on an elevated structure over which such a large number of trains must be operated has been questioned. The through routing of the trains from one road to another would overcome a large part of the difficulty at these crossings, but as the four roads are separately owned such an arrangement is hardly feasible.

Three of the four roads using the loop, the Metropolitan West Side Elevated R. R., the Chicago & Oak Park Elevated R. R., and the South Side Elevated R. R., each have a stub terminal adjacent to the loop, and an ordinance was recently presented to the city council to permit the Northwestern Elevated R. R. to build such a terminal just across the Chicago River from the loop. The stub terminals of the first three roads have been built for some years, although none of them, except the one used by the Metropolitan, have been employed to any extent until recently. Notwithstanding this fact, all of these terminals are situated so passengers bound for certain parts of the loop district could save time by taking and leaving trains at them, and it may be expected that with the regular increase in traffic on the elevated lines that occurs in the Fall the congestion of the loop will become so acute as to cause the patrons of the different roads to appreciate the advantage of the stub terminals.

The only permanent relief of the elevated loop appears to be a system of subways in the downtown districts, such as has been proposed by Mr. Bion J. Arnold. The difficulties that will be encountered in building such subways, however, will unquestionably greatly postpone the time when they are placed under construction. The extensive changes that will have to be made in the public service mains and conduits that completely occupy the streets in the downtown district, and the handling of traffic on these streets during construction are simple matters, as compared with the shoring of the buildings adjacent to the excavations required for the subways. The soft blue clay that extends to a depth of 40 to 60 ft. from the surface over the whole area in which the most necessary subways will have to be constructed is an exceedingly treacherous material to handle. In fact, recent experiences in deep excavations for the sub-basements of tall buildings have shown that this clay will flow under any form of sheeting that can be devised unless this sheeting is carried down to the firm underlying strata before excavation is started. Since the freight tunnels of the Chicago Subway Co. occupy every downtown street at an average depth of 40 ft. below the surface, it is evident that subways for passenger service will have to be built above them in this soft, blue clay. At the same time, such subways are the only permanent means of relieving the present elevated loop, and as the capacity of the latter has long since been exceeded further extension of the various elevated lines tributary to it is useless. The utilization for residence purposes of the great undeveloped outlying districts within the city is limited largely therefore by the relief that can be afforded to the downtown terminals of the elevated railroads.

Coal Selection for Power Plants.

Possibly in no branch of power plant operation are there greater variations in the practice of owners and managers than in the selection of coal for steaming purposes. It is not surprising that this should be so, considering the differences in coal quality found in the open markets and in the mining regions, the discrepancies in freight rates, cost of handling, uncertain effect of storage, and variations in adaptability of fuels to specific boiler-room services. Within the last few years the determination of the heating power of coals by calorimeter and chemical tests has grown much in favor among large consumers, and there is no question that when such work is properly handled the results are of high significance and value, both to the engineer and the technical chemist. But when these tests are made by unskilled hands or with inferior apparatus, and unless the typical samples from barge and car are selected with experienced judgment, the work may be worse than futile, tending to produce warped judgments and decisions unjust alike to the producer and the consumer. These points were emphasized for the special benefit of engineers and public service corporations in a talk on coal economy given by Mr. E. G. Bailey, of the Little Laboratory, in Boston, before the Society of Chemical Industry on Oct. 4.

Emphasis from a chemist on the importance of coal tests by specialists may be *ex parte* judgment, but it hits close to the work when one considers the present uncertain status of the whole problem of fuel combustion. Reduction of fuel bills is one of the perpetual ends which power plant managers are striving to attain, and it is decidedly in fashion nowadays to carry on experiments in the fire room leading toward the use of less fuel by varying the conditions in the furnaces and flues. In some quarters, certainly, the great and encompassing difficulties of the problem do not seem to be realized, and hasty methods, careless observations and inaccurate generalizations have failed to bring the economies expected. It ought to be clear by this time that in the selection of coal for a given service, chemical tests should supplement the experience gained in the fire room, except in special cases where it would be simply out of the question to select other than a certain kind, as in the vicinity of particular mines. Even here much improvement in the situation may spring from a careful series of laboratory tests, particularly with reference to the betterment of firing conditions and furnace structures, draft adjustments and the like. The work may be done by the operating company itself if the organization can afford the quality of apparatus and the technical skill essential, otherwise, it had better be handled by a competent consulting chemist with special knowledge of fuels. To assume that any ordinary assistant steam engineer or electrician in a power plant is competent to sample coal in a representative way and accurately test its calorific power by the calorimeter or by proximate analysis is to invite conclusions that are void of scientific usefulness and are misleading as bases for the settlement of contracts and guidance in future purchases.

Almost any coal will produce steam, but economy in selection starts at the mine, makes certain that the handling is somewhere near right, and figures the transportation charges separately from the net cost of the fuel. Bad results often come from breaking the coal up more than is necessary, and it is not always the coal of highest calorific power which gives the best results in a given shipment. Variations in shipments make it most desirable for the purchaser to know exactly what he is getting. It is sometimes claimed that daily records of coal burned per kilowatt-hour are a sufficient check upon the quality of the fuel, but while such data are useful in running down both sweeping and gradual changes in station performance, they may easily come too late to give the necessary impetus to the required fuel changes. Undue reliance is frequently placed upon the weighing of ashes as a check upon coal quality, in view of the fact that the remaining unburned carbon and also the ashes carried up the stack by a strong draft are neglected. In a carefully made ash test cited by Mr. Bailey, the weight of ashes came short 5 to 10 per cent. of the total ash in the coal, after the unburned carbon was taken out. Under ordinary circumstances, where the carbon is not deducted, the ash frequently runs 25 per cent. higher than the coal analysis shows. As for the ability of the evaporative boiler test to throw a side light upon coal quality, there is no escaping the difficulty which attends the duplication of conditions in regard to firing while the variation of a single condition with the other factors constant is perhaps even more troublesome. Upon the calorimeter and the balances of the laboratory rest the ultimate determination of coal quality.

The diverse factors entering the problem of coal selection render the task a hard one for the layman. The interpretation of the analysis and British thermal unit record remains after the precise methods of the chemist have been applied. There is no question that the higher a coal shows in heat units, the more steam it will generate, other things being equal. It may not, however, be the best fuel for the particular plant in hand. The purchaser naturally desires to get as many heat units per dollar as possible, but there are other points to be considered in the selection of coal. A coal high in sulphur or a fine wet coal tends more readily toward spontaneous combustion and requires more careful watching. In the selection of coal it should be borne in mind that all coal will oxidize more or less, and that so long as the generation of heat can be kept from becoming cumulative, fire will not occur; but if the heat becomes sufficient to drive off the moisture, the danger point has been reached. A closer knowledge of the conditions which lead to spontaneous combustion in coal is much needed at the present time.

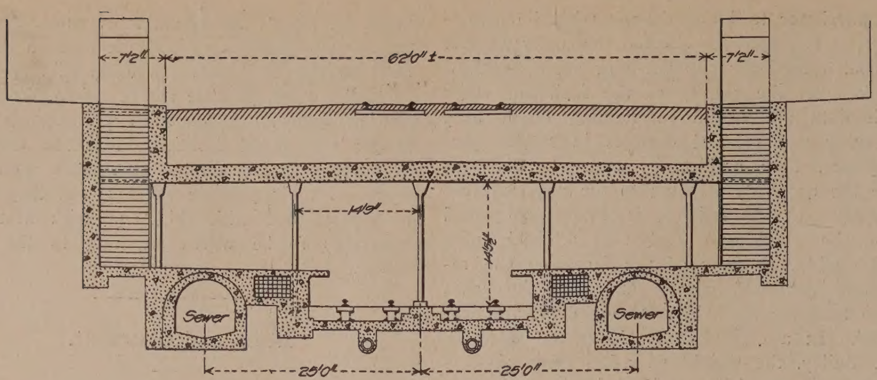
The problems of the boiler-room cannot be divorced from the questions of coal selection in finding out the fitness of a given fuel of known characteristic for a given plant. It is becoming clearer every year that the work of the chemist is but half done when the typical samples are tested. The boiler furnace, tubes, passes and flues are all parts of a laboratory on a large scale and to ignore this is to lose the vital conditions of a particular fuel problem. The cost of handling the coal from the barge to the grates is frequently under-figured. The interest of the fireman is often difficult to arouse unless it is backed up by a bonus for good records and assisted by good scales, a common-sense system of keeping consumption figures, and possibly by the pyrometer and CO_2 recorder. These points must be considered in testing the adaptability of a given coal in actual practice.

The only reason for buying coal on a B. t. u. basis is to make certain that a fair money value is secured on both sides. Coal specifications often set very high limits in calorific power, say, 14,000 B. t. u. as a minimum, and if a great variety of bids are desired this debars fuels which might be excellent for the purpose if investigated, or it possibly admits them under a penalty which artificially raises the price to a point high enough to give the coal dealer a good profit on top of the penalty. If coal of a certain known grade is desired, the limit in B. t. u. need not be as elastic. In cases of large consumption where a wide choice exists, the specification problem demands experience for its proper economical solution. Scientific methods of purchasing fuel do not cost much money in terms of their possible savings, but they must be carried out with skill and with first-class apparatus to be worth anything to the consumer.

Notes and Comment.

Specifications for Incandescent Lamps recently issued by one of the federal departments are interesting as being among the first, if not the first, to employ mean spherical candle power as a basis of comparison. The rating of the lamps called for remains on the mean horizontal candle-power basis, as is customary, but the initial specific consumption called for is 3.76 watts per mean spherical candle, corresponding to 3.1 watts per mean horizontal candle, when the spherical reduction factor is 82.5 per cent. There are many conditions in which increased candle-power in some particular direction is preferable to a nearly uniform distribution, as, for example, the case of a single incandescent lamp, without globe or reflector, suspended above a reading desk. In this case a type of lamp with powerful end-on candle-power with weakened horizontal intensity is preferable to a lamp of the usual type. No proper comparison of the two types of lamp would be possible on the basis either of end-on candle-power or of mean horizontal candle-power. The specification is an important recognition of improvements in lamps and the methods of using lamps, which is particularly significant as the result of long consideration of the subject by the government's staff.

A Contractor's Right to recover for work done under a contract subsequently taken from him has been before the federal courts for some time in an action by the Jonathan Clark & Sons Co. against the city of Pittsburgh. This company undertook to build the Highland Park reservoir in that city, but after carrying on the work for about three years was ordered by the Director of Public Works to discontinue any further construction under the contract. This order was issued in accordance with a contract provision giving the Director the right to stop the work if it was unnecessarily delayed or the contractor was wilfully violating any of the conditions. After the completion of the construction by other parties the contractor sued the city for retained percentages on what it had done and for extras. The city's defense was that no final estimate had been given the contractor by the Director and consequently nothing was due and that the contract specifically provided that the Director should act as an arbitrator in all disputes between the parties to the contract. The U. S. Circuit Court of Appeals has just upheld, 154 Fed. Rep. 464, a decision of the District Court in favor of the contractor. The items claimed by the contractor were sufficiently proved, it is stated, during the trial, and the provision for a final estimate did not apply when the contractor was put off the work. The arbitration clause is also held to be inapplicable in such a case. The city's action under the clause authorizing the Director to order the contractor to leave the work is held to provide impliedly for a determination of the rights of the parties by regular judicial proceedings. The case seems to be a rather unusual one, as shown by the fact that the editors of the "Reporter" could refer to nothing like it in the decisions of any court of final jurisdiction.



Second Street Station of the Market Street Subway.

THE MARKET STREET SUBWAY, PHILADELPHIA.

The Market St. Subway, about 2¼ miles long, is a very important portion of the system of the Market St. Elevated Passenger Ry. Co., the Philadelphia Rapid Transit Co. lessee. This system, as so far planned and authorized, includes about 7½ miles of two and four-track construction, equivalent to about 17 miles of single track. The main line follows Market St. about 6 miles from the Delaware River to 63d St., and east of 24th St., at the east end of the company's bridge over the Schuylkill River, being constructed in subways through the most congested part of the city. That portion of the subway extending from 24th St. to 15th St., together with about 4 miles of the elevated structure west of the Schuylkill River, has already been constructed and trains have been in service since March of the current year, though street cars from West Philadelphia have been running to 15th St. since December, 1905.

The remainder of the structure will consist of both elevated and subway construction, differing somewhat from that already completed, and is now under construction from 15th St., down Market St., to Front St., near the Delaware River, thence on property purchased by the company between Front and Water Sts. to Arch St. and thence along Delaware Ave. about 4,100 ft. to a terminal at the ferries at the foot of South St. Of this portion of the work that which is on Market St., about 1⅛ miles in length, is a two-track subway structure. That portion between Market and Arch Sts., comprising an incline to connect the subway and elevated railway, is partly a reinforced-concrete viaduct, the remainder on Arch St. and Delaware Ave. being double-track elevated steel viaduct structure.

The subway between 15th St. and the Delaware River differs from that on the opposite side of 15th St., chiefly in that it is two-track instead of four-track, in the roof construction and in the methods employed in building it. Between 15th St. and 22d St. the subway, which was illustrated in The Engineering Record of February 25th, 1905, has a standard cross-section 48 ft. 6 in. wide inside and 14 ft. high above tops of rails, and is made with massive concrete side walls and inverts, the former reinforced with vertical and horizontal rods near the inner surface. The roof is made with transverse 5-ft. concrete arches reinforced over the tops of the beams only with wire cloth to prevent temperature and shrinkage of cracks, and supported on 20-in. I-beams carried by the sidewalls and by three intermediate rows of riveted columns. The structure was built in three successive longitudinal sections, the first two being made in open trench and including the side walls and part of the inverts to include the outside tracks. The excavation for the middle section of the structure was made by drifting and tunneling under the two surface tracks.

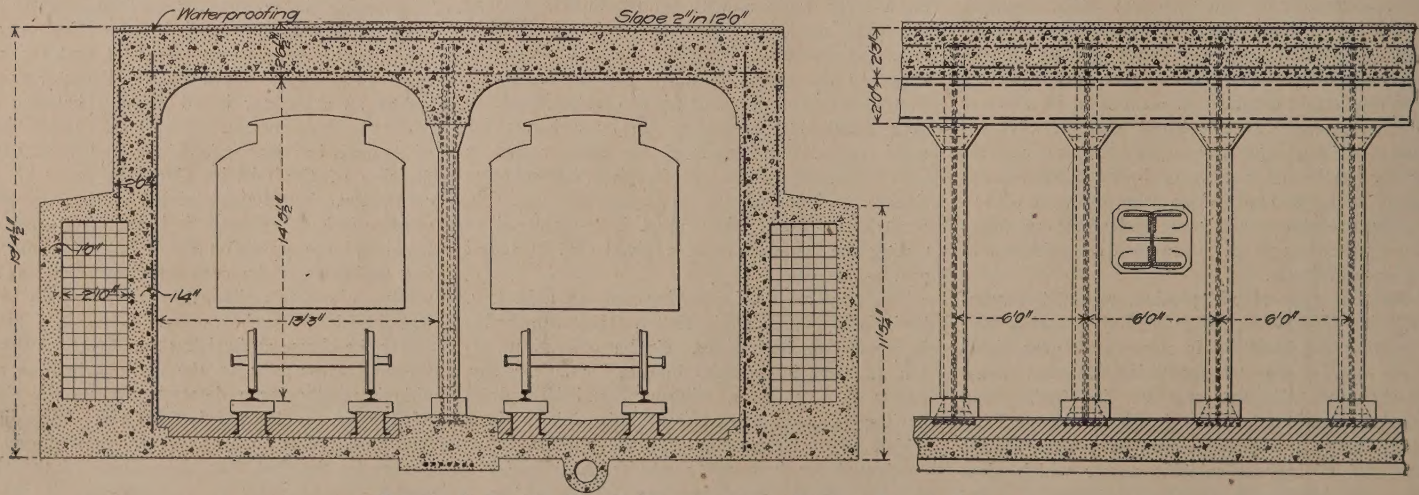
At its intersection with Broad St., between 13th and 15th St., the continuity of Market St. is interrupted by the City Hall, which occupies an area about 450 ft. square and approximately on its center line. It is an extremely heavy stone building, six stories high, with a tower about 538 ft. high, imposing very heavy loads on its foundations, on account of which, and the character of the soil, it was determined not to attempt to carry the subway underneath the structure, as is the rational alignment, but to diverge on both sides of it, thus forming a rectangular belt enclosing the City Hall, with substantially the same location as that of the present surface tracks. Provision is also made with this belt for connection with lines north and south on Broad St., and as the location was limited by the boundaries of City Hall Square, nearly all of the tracks are on curves with short tangents, which together with the cross-over switches and connections for future branches and provision for passing and connecting the express and local service, has made a very complicated construction which is too elaborate for other than a very general description in this article.

By "express" service is meant that of the trains which pass to and on the elevated railway, and "local" service includes that furnished by the street cars which enter the subway from the surface tracks in West Philadelphia.

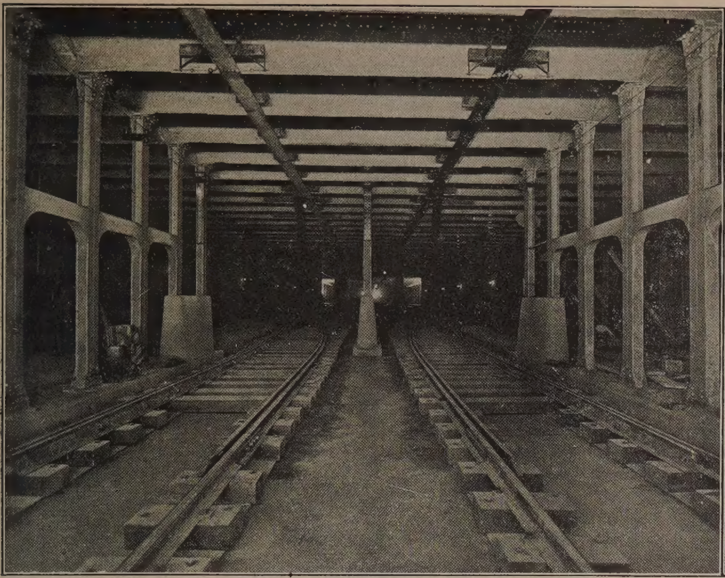
Between 15th and Broad Sts., the subway is about 70 ft. wide between outside passenger platforms and about 90 ft. wide between the main walls of the passenger station located there. The center tracks are used for express service and the outside tracks for local service, and both of them make a complete loop around City Hall Square, thus avoiding stub ends and providing for the continuous operation of trains in both directions from the 13th and 15th St. stations, respectively, to the terminals, and for looping the local cars about the City Hall, and as no provision is made in the subway for the local cars east of City Hall Square.

On the 13th St. side of City Hall Square the tracks for trains converge by curves through 90 deg. to meet the two tracks in the subway on east Market St., with switches and connecting track to allow the looping of trains from and to the tracks west of the City Hall. The tracks for the local cars on the east side of the City Hall run under the express tracks where the latter swing into the Market St. line. This arrangement provides for the express service to be continued on Market St., the east and westbound trains passing around City Hall Square, to the south and north, respectively. At both intersections with Broad St. there are two curved connections with the local tracks for future double-track subways in Broad St. The elevation of the express track varies from + 11 to + 17, that of the curb varying from about 34 to 41. The lowest elevation, about 0, is where the local tracks pass under the express tracks at Juniper St.

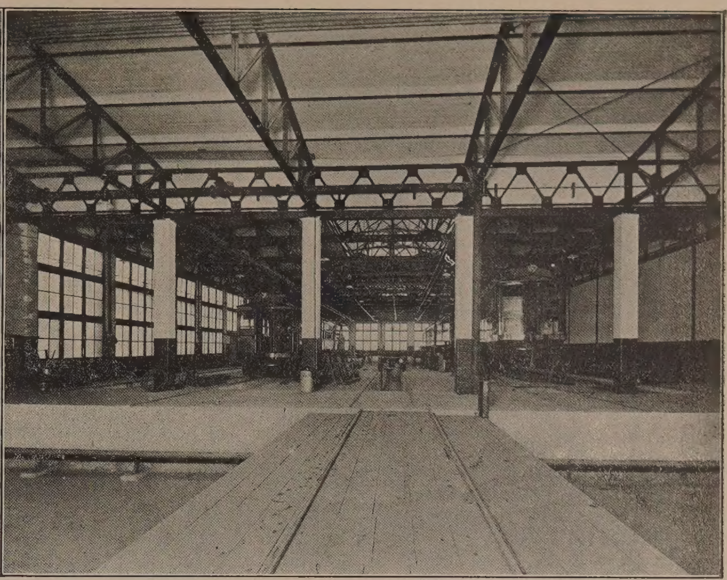
The subway has everywhere reinforced-concrete side walls and roof, the invert being reinforced below the ground water level, and is built with one row of columns where there are two tracks, the columns being omitted at the cross-overs. At the curved sections at the northeast and southwest corners of the City Hall Square, where the express and local tracks are at different elevations, there are no columns, and the roof is supported entirely by concrete wall S. The cross-section is everywhere rectangular and is a continuous integral structure whether the tracks are at the same or different elevations or in case of a cross-over or two-story track, and where there is a passenger subway underneath the track. Be-



Standard Double Track Construction, Market Street Subway.



Approach to 19th Street Station and Temporary Crossovers.



Car Repair Shop and Transfer Table at 69th Street.

tween the curved lines of Market and Broad Sts., at their intersection with City Hall Square, the walls of the subway form very large triangles and the roof is supported by a number of extra interior columns.

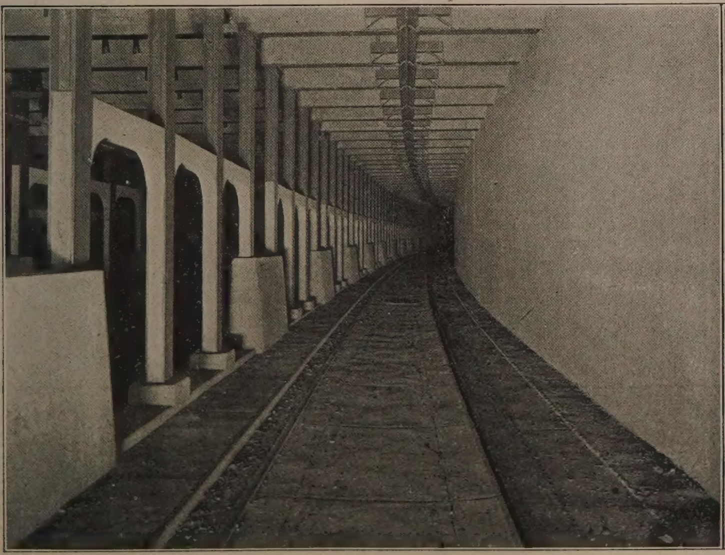
Besides the 15th St. station there are five others located at 13th and 11th, 8th, 5th and 2d Sts., all of them of the same general type with platforms having an effective length of 350 ft. on opposite sides of the two-track section and entrances on both sides of Market St. The station at 15th St. has four passages from the express platform to the street above the level tracks and below the street surface. It also has a direct entrance through the basement of the Broad St. station of the Pennsylvania Railroad. The 8th St. station, at the center of the retail drygoods district, is 400 ft. long over extreme end structures and is made with spacious platforms extending laterally to include the vaults under the sidewalks, thus increasing the width to 100 ft. The platforms are connected by two passageways over the tracks and below the street surface. The 5th St. station is about 80 ft. wide, and is of simple construction, with one row of columns between the tracks and two rows on each side of them, and has a large main sewer adjacent to each of the outside walls. The 2d St. station is about 80 ft. wide and is also made with five longitudinal rows of columns and has a 7½-ft. main sewer under each of the passenger platforms, manholes being provided for them at each end of the station.

The standard double-track subway between 13th and 2d Sts. has a rectangular cross-section 30 ft. 6 in. out to out of walls and about 37 ft. wide over the duct construction, which varies in height above the floor and is 20 ft. deep over all with a flat concrete invert and reinforced-concrete vertical sidewalls and flat roof with a center row of riveted steel H-shaped columns 6 ft. apart on centers. The subway is 26 ft. 6 in. wide and about 15 ft. high inside with a longitudinal tile drain bedded in the concrete under the center of one track. Except under column footings, the invert is 11 in. thick, without reinforcement where above the ground water level. Below the ground water level the floor is thickened and reinforced to resist hydrostatic pressure.

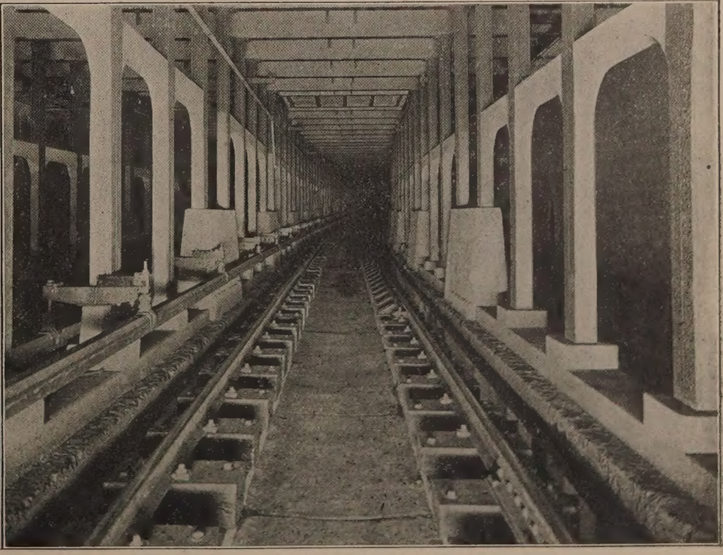
The sidewalls are 2 ft. thick, except when they are enlarged, and have hollow spaces for the reception of the ducts, with vertical bars 12 in. apart and with horizontal bars 12 in. apart in two staggered rows near the inner and outer surfaces of the wall. The roof is reinforced with one tier of horizontal transversed rods 6 in. apart on centers extending the full width from sidewall to sidewall, 3 in. above the lower surface of the concrete. There are also horizontal longitudinal rods 12 in. apart in each of two staggered tiers, which are made in 30-ft. lengths overlapping 2 ft. at each end. Additional transverse bars, 12 ft. long, are placed over the tops of the columns, and six lines of bars are placed in the longitudinal concrete girder which forms an integral part of the roof in the planes of the columns. In each sidewall a rectangular space, the maximum size of which is 2 ft. 10 in. wide and 8 ft. high, is occupied by 96 electric ducts, the size of the space and the number of ducts varying along the line.

The corners between the roof and sidewall concrete have a concrete cove or fillet with a 2-ft. radius, and sockets are built in the roof to provide for the support of a possible future trolley wire. The columns are made with four 5x3-in. angles, and have four 6x3⅜-in. tie plates besides the top and bottom web plates connected with the caps and bases, and are embedded in solid 10½x 14-in. concrete jackets. The concrete protection is reinforced and secured to the columns by ¼-in. bent rods like cotters through the column webs and by curved sheets of 3-in. mesh expanded metal wired on as indicated in the detail, and serves in place of usual web plates or latticing. The design of the track conforms to that installed in the subway on West Market Street, each rail being supported on 6x6-in. ties 2 ft. long and 2 ft. apart on centers, which rest on the tops of a pair of 12-in. channels 15 in. apart back to back bedded in 12-in. concrete laid over the top of the invert.

On curves and at crossovers pairs of columns are protected against collision and derailed trains



Local Track Section near West Portal.



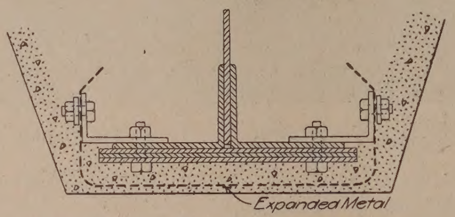
Express Track Section near West Portal.

by concrete piers enclosing them to a height of 4 ft. above the rail base and having a thickness of 18 in. at the top and 24 in. at the bottom. They are made with rounded corners and are reinforced with a pair of 3/8-in. horizontal rods forming a complete loop enclosing the columns.

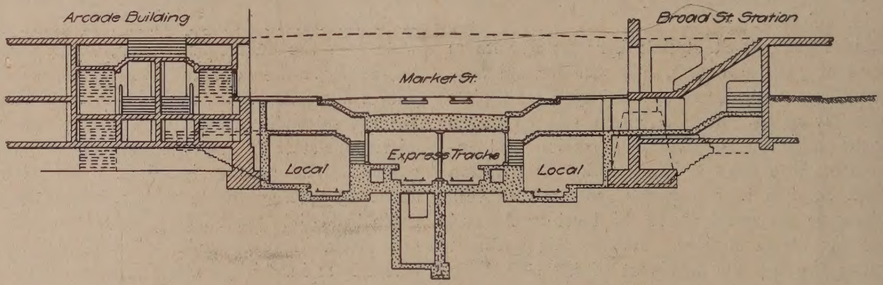
On the curved portion of the subway about the City Hall the collision piers are 18 ft. apart on centers and the two unprotected columns between them, together with the adjacent end columns of each pier, are connected by a line of three continuous horizontal longitudinal concrete struts, about 6 in. wide and 8 in. deep, engaging the webs of the columns at a height of about 8 ft. above the rail bed. Above these struts the columns are not concreted.

At cross-overs the center columns are omitted to clear the tracks, and the thickness of the roof slab is 3 ft. 1½ in., which is increased to 3 ft. 6½ in. by 1 in. of waterproofing and 3 in. of concrete protection over the waterproofing, for a clear span of 26½ ft. The span, however, is practically reduced by the deep covers at each wall, which act as continuous corbels. The reinforcement consists of two tiers of transverse rods, each tier 3 in. inside of the top and bottom of the main concrete, respectively, and three tiers of longitudinal rods, one in the center and one near each surface, inside of the transverse rods. The lower main rods are bent up at their ends, the spacing being 4 in. for the transverse rods.

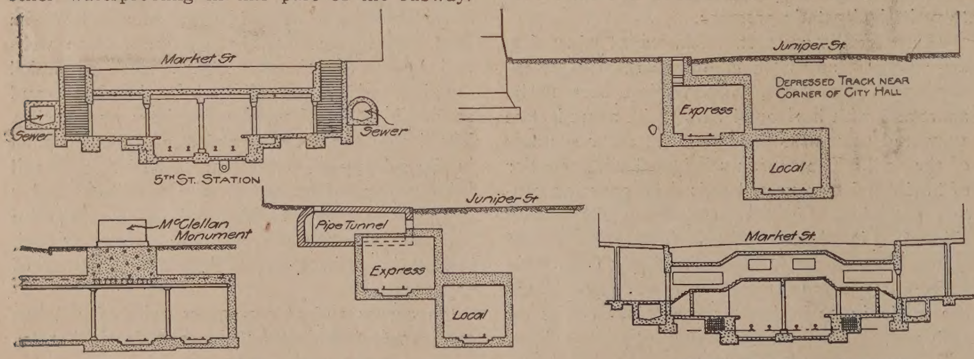
The shallow roof construction differs from the standard construction in that it is only 24½ in. thick and in that the tier of 12-ft. transverse rods is replaced by a tier of full-length transverse rods. The lower tier of transverse rods in the roof over the cross-overs has one 1.56 sq. in. cross-section, all other main transverse rods have 1 sq. in. cross-sections and all are of the twisted type. A layer of asphalted mastic waterproofing 1 in. thick is placed on the roof and is covered by a layer of concrete 3 in. thick. There is no other waterproofing in this part of the subway. The surface of the roof slopes 2 in. in 12 ft. from the center to each side.



Girder Flange Protection in Subway.



Four-Track Subway Station near City Hall.



NORMAL AND DEPRESSED TRACKS ON CURVES AT CITY HALL

8TH ST. STATION AND CROSS OVER

Subway Construction at Stations and on Curves.

The quantities involved per lineal foot in the construction of the standard two-track subway are as follows: About 38.1 cu. yd. of excavation, 7.8 cu. yd. of concrete, and 574 lb. of steel reinforcement, and 206 lb. of structural steel. The structure was designed by the Engineering Department of the Philadelphia Rapid Transit Co., Mr. Wm. S. Twining, chief engineer; Mr. C. M. Mills, principal assistant engineer. The contractors are the E. E. Smith Contracting Co. for the City Hall section, and the Millard Construction Co. for the section from the City Hall eastward toward the Delaware River.

A DIAMOND DRILL BORE-HOLE 6,700 ft. deep was put down in Upper Silesia in 1900, according to a note in The Engineering and Mining Journal. Another deep hole was put down on the Rand, South Africa, in 1905, the depth being 6,304 ft.

The Garbage Reduction Process at Toledo.

The garbage of Toledo, Ohio, is treated by the Edson reduction process, which furnishes two commercial products, grease and tankage. The garbage tankage is used by manufacturers of commercial fertilizers, and is sold at an average price of $9 per ton at the plant. The garbage grease is sold to soapmakers and brings about $80 per ton f. o. b. cars at the plant. The works have been under the charge of Mr. Thomas R. Cook as receiver during the past year, and at the recent meeting of the Central States Water-Works Association he read a paper concerning them, from which the following notes are taken. The fact that the company had to go into the hands of a receiver is a pretty strong commentary on the commercial aspect of garbage reduction under the existing local conditions.

The apparatus used in the process consists of hermetically sealed digesters, dryers and grease extractors. Two digesters and one dryer constitute what is known as a unit and are supposed to be capable of treating 20 tons of raw garbage every 24 hours. There are three units at Toledo, and consequently a total capacity of 60 tons in 24 hours. The delivery of garbage to the plant during summer months averages about 45 tons daily, and during the winter months about 30 tons daily, and consequently the plant has never been forced to its full capacity.

The raw garbage is delivered in steel wagon boxes, so constructed that a box can be picked up with an electric crane, hoisted to the fourth, or charging, floor, and there dumped into bins of concrete. The box is then thoroughly cleansed and cleaned by hot steam and returned to the wagon, the whole operation consuming less than five minutes.

The next step is to charge the digesters with this raw material, which is done through galvanized iron pipes running from the charging floor into the digesters on the floor below. When the digesters are filled they are sealed up, the steam is turned on, and the mass of garbage undergoes sterilization and disintegration for a period of about 9 hours. During this time the heat is regulated by air pressure upon the surface of the material, and no boiling occurs within. A valve is now opened and the mass is dropped through a sleeve into the dryer waiting to receive it. It is dried by external steam heat and the maintenance internally of a vacuum during the drying process, which lasts about 12 hours. The original mass of material is now dry and is discharged automatically from the dryer in the form of unpercolated tankage, or, in other words, tankage from which the grease has not been extracted.

During the entire process up to this stage this material has been under steam pressure and not once exposed to the air. All foul gases that arise during the operation are passed through a deodorizer for that purpose, and thence into the combustion chambers under the boilers. The unpercolated tankage is now conveyed by means of elevators and conveyors to the third floor of the grease extracting department, where it is ready to be put through the percolating process, which consists of cold filtration, using naphtha as a solvent. The material is fed through a galvanized iron pipe into the percolators, of which there are two, each having a capacity of about 5 tons of unpercolated material every 12 hours. The percolator being filled, it is then sealed, and naphtha pumped into it until the material is entirely flooded. It is allowed to stand for a certain length of time, and the naphtha and grease together are pumped out and into separating tanks, which are provided with mushrooms heated enough to vaporize the naphtha, which is conducted through vapor lines to the condensing tank, changed into liquid form and used again. The grease is then pumped into storage tanks. This process is repeated until the whole mass of material in the percolater is thoroughly percolated and the grease entirely removed.

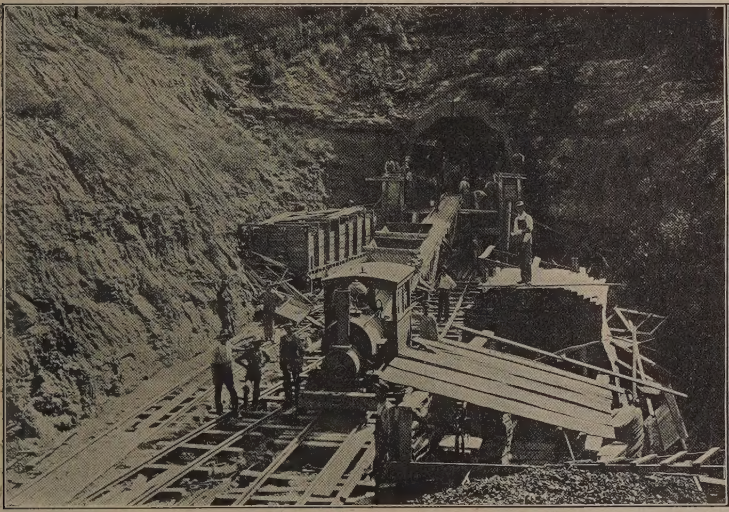
The material is now ready to dry, which is accomplished in the same receptacle by external steam heat, thorough agitation and the maintenance of a vacuum. The dry tankage is now discharged automatically from the percolater and taken by means of an elevator and conveyors to the storage room, where it is ready to be shipped out for use in the manufacture of fertilizers. The percolating process consumes from 6 to 7 hours and the drying from 4 to 5 hours.

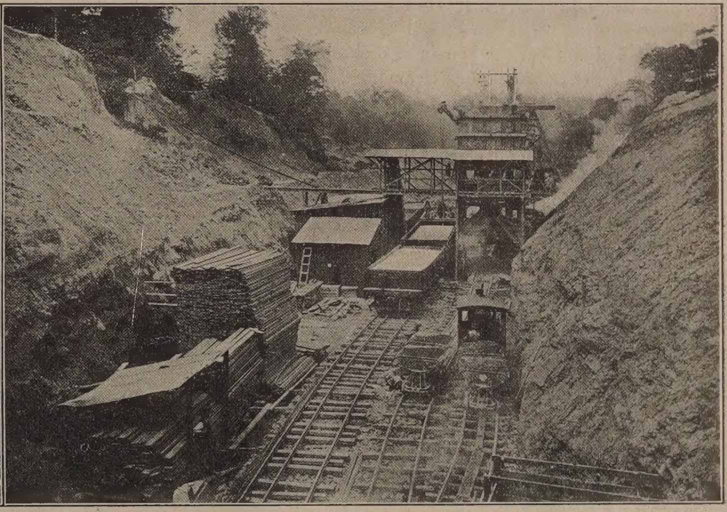
Using as a basis the class of garbage received in Toledo, which is not of the best, the amount of finished tankage from raw garbage is about 17 per cent. and of grease is about 3 per cent. This system will handle dead animals, bones and anything in the way of organic matter, in addition to garbage.

Lining a Tunnel With Concrete.

The Jasper-French Lick extension of the Southern Ry. in the southern part of Indiana includes a single-track tunnel, 2,200 ft. long, at a point about 4 miles from French Lick. The tunnel is on a 4-degree and 30-minute curve for 300 ft. at one end, with the remaining 1,900 ft. on tangent. It was driven through slate and soapstone rock, which had to be closely timbered throughout as the headings advanced from both ends. The timbering used in the tunnel consisted of local beech, the intention being at the time it was finished, about a year ago, to line the tunnel from end to end with concrete. The placing of this concrete lining was started in June of this year, and from the results that have thus far been attained, it is reasonable to expect that it will be completed by October 31, although the work had to be shut down for a month, and the slow delivery of concrete materials occasioned considerable delay while it was in progress.

The dimensions of the tunnel and the details of the lining are shown in the accompanying cross section. The tunnel was driven to a clear width of 21 ft., and a height of 26 ft. 3 in. at the center line, both measured to the outside limits of the timbering. Inside the latter the clear height at the center line was 24 ft. above the sub-grade, and the clear width 18 ft. After the concrete lining is placed, the clear width is 16 ft. and the clear height above the rail is 22 ft. at the center line, the arch being semi-circular, with a rise of 8 ft. The timbering consists of 10x12-in. uprights, spaced 3 ft. apart on centers, and carrying 10x12-in. horizontal wall-plate timbers, on which are placed 10x12-in. arch ribs, also set 3 ft. apart on centers. The upright timbers are on 3x12-in. sills, and are lagged with 3x6-in. plank, while the arch ribs are lagged with 4x6-in. plank.


Looking toward Tunnel Portal from Mixing Plant.


Looking toward Mixing Plant from Tunnel Portal.

The concrete lining has a floor approximately 14 in. thick, that is laid on the sub-grade of the tunnel. The track ballast is confined between two concrete curbs, 12 in. high. These curbs are built as a part of the floor, and are 1 ft. 10 in. from the side walls, thus forming a drain, 1 ft. x 1 ft. 10 in. in cross section, at each side of the tunnel. Weep holes, consisting of 3-in. vitrified tiling, spaced 20 ft. apart in the base of the side walls, open into these side drains. The side walls of the lining are 2 ft. thick, the arch decreasing from 2 ft. in thickness at the springing lines to 18 in. at the crown. The side walls and arch are reinforced, 3 in. from each face, with a row of ¾-in. Johnson corrugated bars, spaced as shown in the cross section. The timbering is enclosed in the concrete lining, the reinforcement bars being arranged to avoid it. The lining requires 4.132 cu. yd. of concrete and 181.45 lb. of Johnson bars per linear foot of tunnel. The concrete was made in the proportions of 1 of Lehigh cement, 2½ of sand and 5 of crushed stone. Screened crushed stone, all of which would pass a 2-in. ring and be retained on a screen with ½-in. meshes, was used.

The concrete lining was all carried forward from one portal of the tunnel. A complete plant for handling and mixing the concrete materials was erected near that portal, and a very satisfactory arrangement for delivering the concrete from this plant into the forms for the lining was developed. The concrete materials and other supplies were brought to the tunnel in standard-gauge cars, operating over the track that had been laid to French Lick.

The plant for handling and mixing the concrete materials was about 200 ft. from the adjacent portal of the tunnel. A low, temporary trestle, 500 ft. long and carrying an 18-ft. gauge track, was placed back of the mixing plant, in the cut which forms the approach to that portal. This trestle was 20 ft. to one side of the standard-gauge track laid in the cut, the space between it and the track being floored over, so sand and stone could be stored on it. A stiff-leg derrick and a hoisting engine were mounted on a platform traveling on four double-flanged wheels on the wide-gauge track on the trestle. This derrick has a 65-ft. boom carrying a 1-yd. orange-peel, or a 1½-yd. clam-shell Hayward bucket. This boom, with the travel of the platform, gave the derrick a range for unloading sand and stone from gondola cars on the track to the storage piles, or directly to two 20-yd. supply hoppers at the foot of two inclined bucket elevators, which raised the materials to storage hoppers of the mixing plant. The sand and stone stored in the piles at the side of the trestle were loaded into 2-yd. dump cars on a narrow-gauge track at the same level as the trestle track, with the orange-peel bucket, and were delivered to the supply hoppers of the elevators by these small cars. During most of the time that work was in progress, however, crushed stone could not be obtained fast enough to permit any accumulation in storage piles, so most of the stone was unloaded from the cars directly into the supply hoppers of the elevators by the derrick.

The concrete mixing plant was erected on the same side of the track as the trestle carrying the traveling derrick. Two storage bins, with a capacity of 85 cu. yd., one of which was for sand and the other for stone, were placed on a timber tower, with their bottoms 25 ft. above the grade of the track. One of the bucket elevators delivered sand to one of these bins, and the other carried stone to the second bin. A working platform on which the concrete materials were measured in a charging hopper, was built directly under the storage bins. A shed for storing cement was erected on the opposite side of the track from the mixing plant, because no other space was available. The cement was raised from this shed to a bridge over the main-line track by a bag elevator, the bridge extending to the charging platform under the storage bins. The bags of cement were delivered on a flat car by the elevator, and were carried to the charging hopper on this car, which ran on a track on the bridge.

A 1½-yd. cubical concrete mixer was placed directly under the hopper in the charging platform, the mixer engine being at the level of the track. The mixer was set high enough so 1½-yd. Koppel dump cars could be run under it on a 3-ft. gauge track. This track was extended through the tunnel, to facilitate the delivery of the concrete.

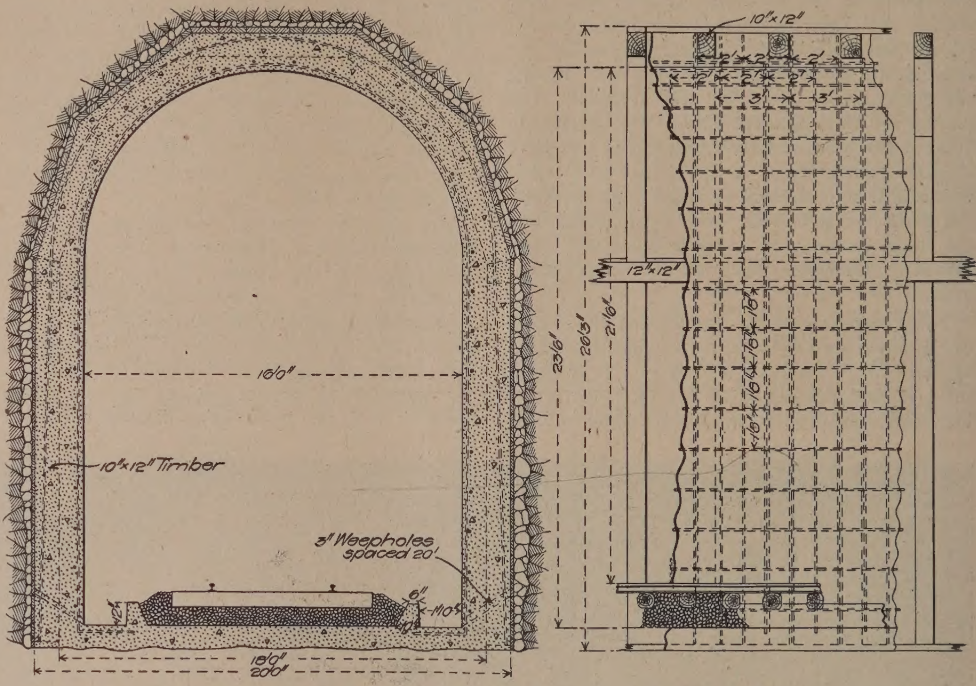
The floor of the tunnel lining was laid first, the work being started at the portal farthest from the mixing plant. The concrete was delivered to place in the 1½-yd. dump cars, which were handled by a light locomotive. As the floor was carried toward the portal at the mixing plant, the 3-ft. gauge track that had been laid in the tunnel was raised and suspended from timbers placed across the latter until the concrete had set. When the floor had been finished, a standard-gauge track was laid on it, with a third rail for the narrow-gauge track, and work was started on the side walls.

A special arrangement for handling the construction of the side walls and arch, which proved specially advantageous, was adopted. Two standard-gauge flat cars were attached together, end to end, and far enough apart so a working platform about 100 ft. long could be erected on them. This platform was made just wide enough so it would comfortably clear the forms for the side walls of the tunnel, and was placed at such height that concrete could be shoveled from it directly into the wall forms, up to the springing lines of the arch. An incline, about 60 ft. long, extending from the level of the standard-gauge track to the platform on these cars, carried a 3-ft. gauge track, which was continued the full length of the platform. This incline was built with a trussed under-frame, carried, independently of the cars, by two pairs of wheels. It was attached to the platform at the upper end by heavy hooks, and was arranged with a detachable section at the lower end. The loaded 1½-yd. Koppel cars were brought to the foot of the incline from the mixing plant by the light locomotive, which also pulled them up the incline by means of a cable rove through a block anchored on the working platform. The concrete was dumped on the platform from the cars, and was then shoveled down into the wall forms, the tops of the forms being at about the same level as the working platform. The walls were finished for about 100 ft. to the full height in this manner while the cars were in one position. The portable section of the incline was then removed, and the incline and platform cars were moved along to the next length of the wall by the light locomotive. As the cars were merely blocked in position while concrete was being placed, they could be moved ahead without interrupting the progress of the work more than a few minutes.

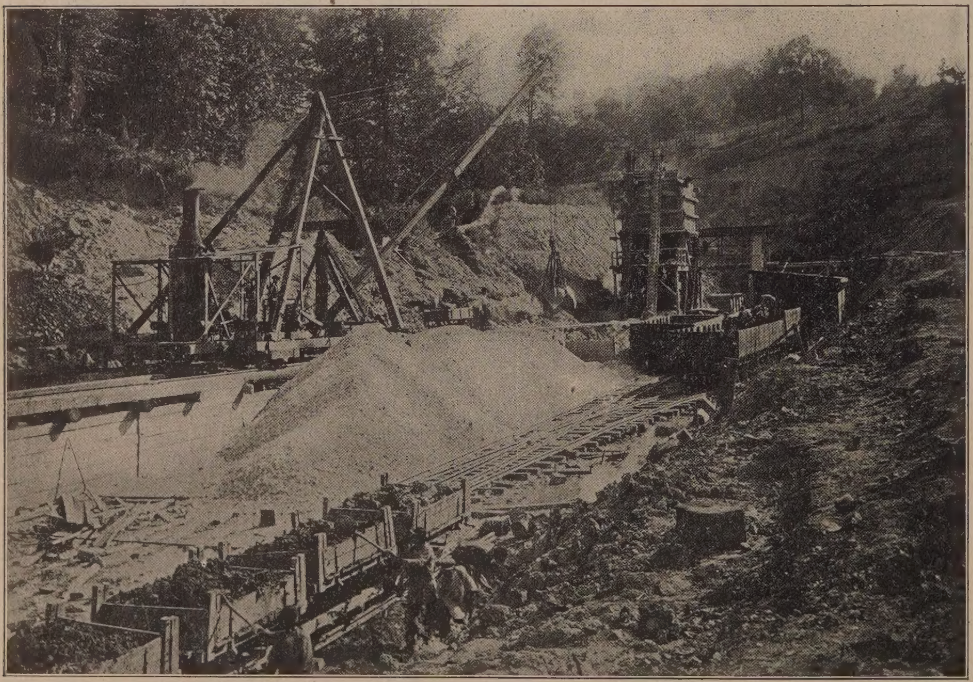
The forms for the side walls had 4x6-in. uprights, spaced 3 ft. apart on centers. These uprights were reinforced at the center by a 6x6-in. waling, which was attached to the plumb posts of the timber lining with lag bolts extending through the concrete wall; they were also attached to the timbering at the top by short pieces of plank, and were lagged with 2x12-in. plank, dressed on one side. The wall forms were allowed to remain in place at least 48 hr., after which they were carried ahead to be used again.

After the side walls had been completed, the platform on the two flat cars was raised until the 1½-yd. dump cars, when in a dumping position, would just comfortably clear the forms for the arch. Concrete work on the latter was then started at the portal distant from the mixing plant and was carried forward toward the other portal. The forms for the arch had 6x12-in. ribs, cut to conform with the curve of the arch intrados. These ribs were carried at each end on a horizontal 6x12-in. timber resting on 6x6-in. posts erected against the side walls already completed. A 6x6-in. waling timber was also placed along the foot of the ribs on each side of the arch, and was anchored to the timber lining by lag bolts, so the ribs were sustained without cross braces in the tunnel. The lagging of the arch ribs consisted of 2x6-in. plank in 6-ft. lengths. These plank were carried up on the sides of the arch just ahead of the concrete, until a space 18 in. wide was left at the crown of the arch. Lagging in 3-ft. lengths was then used to finish out the forms at this opening, the closing section of concrete being shoveled from the platform into place from the end of each 3-ft. section. Work on the arch was carried on day and night, in order that the closing section could always be placed before the concrete in the balance of the arch had set. An electric lighting plant was installed to expedite the night work, and also the work in the interior of the tunnel. The ease with which the working platform could be moved, the opportunity to handle the concrete work rapidly and the absence of any cross braces in the tunnel greatly reduced the number of men required and facilitated the progress of the work.

The general contract for the construction of the Jasper-French Lick extension of the Southern Ry. was awarded to MacArthur Bros. Co., of Chicago, which company built the tunnel and erected the timber lining. The concrete lining is being placed, under a sub-contract, by the Cullen-Friestedt Co., of Chicago, the plant and methods described herewith having been developed by the latter company. Mr. J. B. Anderson was engineer in charge for the railway company.



Cross Sections of Concrete-Lined Tunnel on Southern Railway.



Traveling Derrick for Handling Concrete Materials from the Cars.

Economy Tests of a 7500-Kw. Westinghouse-Parsons Turbine.

The following data comprise the principal results obtained on Sept. 1, 1907, during an 8-hour economy test upon turbine No. 253, installed earlier in the year, at Waterside Station No. 2 of the New York Edison Co. This test was conducted entirely by the New York Edison Co., under the direction of Mr. J. P. Sparrow, chief engineer. The various arrangements therefor were carried out in accordance with a mutual agreement between builder and operator, entered into previous to the test, and the results, as herein given, were obtained by independent computation.

The turbine unit tested is of standard Westinghouse construction throughout. It has a maximum rated capacity of 11,250 kw., and was built to operate on 175-lb. steam pressure, 28 in. vacuum and 100° superheat. Under these conditions, the turbine unit was guaranteed to have a minimum steam consumption of 15.9 lb. per kilowatt hour at the generator terminals with a normal speed of 750 r. p. m. Incidentally, the electrical efficiency of the generator was guaranteed to be 97.8 per cent., exclusive of friction and windage, at a load corresponding to that sustained during the test. The results of the test detailed below show an economy about 7.5 per cent. better than the guarantee.

During the test period, No. 2 Waterside Station sustained practically all of the 25-cycle load on the system, of which the unit under test carried practically 70 per cent., the remainder being taken by the other turbine units in the station. This load was maintained as constant as possible by remote control of the turbine governor by the switchboard operator. Between the first and the last hours of the test, the maximum variation in load was held within 4 per cent. above and below mean. During the last hour, however, the load decreased somewhat. Previous to the test, this turbine unit had been running on a load of 7,000 kw., which was increased to its test load ten minutes before the start of the test.

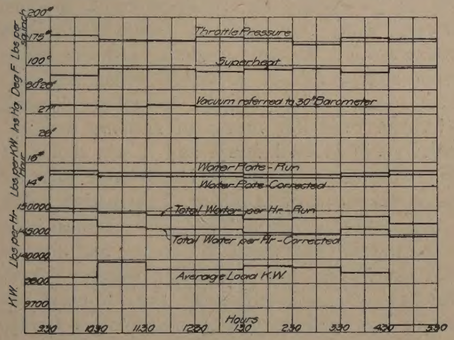
Three-phase electrical load was measured by the two-wattmeter method, using two Weston indicating wattmeters of the standard laboratory type. These instruments were calibrated at the

New York Electrical Testing Laboratories immediately before and after the test. Power factor was maintained substantially at unity, and all electrical readings were taken at one-minute intervals.

As a surface condenser was used in connection with this turbine unit, the water rate was determined by weighing the condensed steam delivered from the condenser hot well. This condensation was weighed in a tank mounted upon platform scales, with a reservoir above large enough to hold the condensation accumulating between each weighing, the arrangement being shown in the accompanying sketch. These weighings of 12,000 to 13,000 lb. each were made at intervals of five minutes.

By the loop method of connecting the gland water supply, shown in the attached sketch, the necessity for correcting condensation by an amount equivalent to the weight of the gland water used is avoided. It will be noted that a continuous gland water circuit is used entirely outside of the weighing apparatus, and that all overflow from the standpipe returns to the hot well delivery.

As the circulating water is quite salt, any condenser leakage may immediately be detected by the salinity of the condensed steam, which should be pure distilled water. On this account, condenser leakage was determined entirely by chemical analysis, employing the silver-nitrate test with a suitable color indicator. This method proved extremely sensitive, and possessed a decided advantage over the ordinary method of weighing the leakage accumulating during a definite period when the condenser is idle and under full vacuum. As samples of circulating water and condensed steam could be taken at the same time, this method made it possible to discover any change in the rate of condenser leakage taking place during the test, while the method of weighing above described provides only an average result during the period.



Log of Turbine Test.

In this condensing plant, the delivery of the hot-well pump is automatically controlled by a float valve in the interior of the hot well. This maintains the water level therein at a practically constant point, and hence no correction had to be made for difference in level of water in the hot well before and after the test.

Steam pressures and temperatures were determined close to the turbine throttle. As usual, the degree of superheat was obtained by subtracting from the actual steam temperature the temperature of saturated steam at the corresponding pressure carried at the time. All gauges and themometers were calibrated previous to the test at the U. S. Testing Bureau. It will be noted that both pressure and superheat were somewhat below the guarantee.

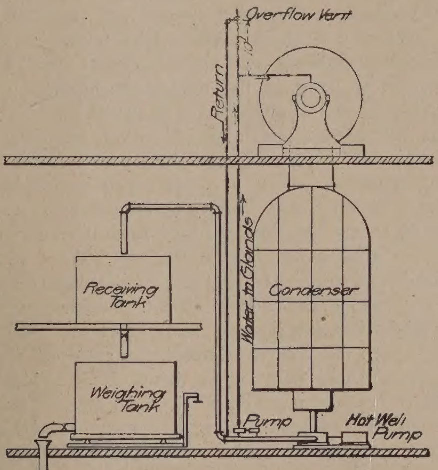
Vacuum was measured directly at the turbine exhaust by means of a mercury column with a barometer alongside for reducing to standard barometer, 30 in. This also obviated the necessity for temperature correction between the two mercury columns. During the test the vacuum was not maintained quite up to normal.

The following data represents the average results of the tests, calculated for the conditions as actually run; i. e., for instrument errors only: Duration of test, 9.30 a. m. to 5.30 p. m.; steam pressure at throttle, pounds per square inch gauge, 177.5; superheat at throttle, deg. F., 95.74; vacuum (referred to 30" barom.) in mercury, 27.31; load on generator, kw., 9830.48; steam consumption, as tested, pounds per kw. hour, 15.15.

Owing to the departure, during the test, from specific operating conditions upon which guarantees were based, it was necessary to correct the observed results by the following amounts:

Pressure (2.5 lb. high) correction, 0.25; vacuum (0.69 in. low) correction, 1.84 per cent.; superheat (4.26° low) correction, 0.29 per cent.

These corrections were mutually agreed upon previous to the test as representative of this type of turbine. When applied to the observed steam consumption given above, the following results, representing contract conditions, are obtained:



Method of Weighing Condensation.

Average corrected water rate during 8-hour test, 14.85 lb. per kw. hr.; guaranteed water rate, 15.9 lb. per kw. hr.

Referring now to the accompanying log, it is interesting as a check upon the average figures above presented, to observe the results segregated into hourly periods, as shown. Here it will be noted that the load was considerably lower during the first and last hour than during the main part of the test. Neglecting, therefore, these two hours and considering only the six hours period from 10.30 a. m. to 4.30 p. m., the results are as follows: Average corrected water rate, 14.8 lb. per kw. hr.; equivalent water rate, 10.65 lb. per bhp. hr., or 9.8 lb. per ihp. hr. The two latter quantities are determined by applying conversion factors for generator efficiency and for internal losses.

In connection with these tests, a noteworthy agreement exists between the results noted and those previously obtained from tests of machines of similar design installed in the Manhattan Station of the Interborough Rapid Transit Co., New York, and the Long Island City Station of the Pennsylvania R. R. At the same loads and with equivalent operating conditions, the performance of the machines is almost identical. These economic results, while not exceeding in actual steam consumption the best records of European practice, yet are extremely good in view of the moderate operating conditions under which the test was conducted. In fact they are considered by the builders to represent the best results that have yet been obtained by any turbine under the conditions named.

The Government of Formosa is organizing an irrigation bureau and has sent an engineer to study methods of the U. S. Reclamation Service.

Concrete Work at Charles River Locks.

The locks in the Charles River dam at Boston are being constructed by the Holbrook, Cabot & Rollins Corporation, and in the last report of Mr. Hiram A. Miller, chief engineer of the commission in charge of the work, there are some notes concerning the manner in which the concrete was handled. Gravel from the harbor and Shirley Gut was brought by scows and dumped in the river bed at one end of the coffer-dam surrounding the site of the locks. From there it was raised by an orange peel bucket to a 16 x 14-ft. hopper, with its top about 70 ft. above the bottom of the lock. From this hopper the material passed over four screens set at an angle of 1 to 12, which separated it into sand and stones which were deposited in bins of 120 and 200 cu. yd. capacity. Below the bins were the measuring hoppers for getting the proper quantity of sand and gravel. After leaving the hoppers, the sand and gravel passed to a 24-in. belt conveyor about 90 ft. long, which carried the mixture, together with the proper amount of cement, to a hopper over a cubical mixer holding a little over 2 cu. yd. From the mixer the concrete was dumped into bottom-dumping boxes holding about 2 cu. yd., mounted on trucks running on a track and operated by an endless cable.

The boxes were handled by a bull-wheel derrick on a platform at the elevation of the top of the lock walls, and carried on wheels running on rails laid on heavy timbers on each side of the bottom of the lock. The forms for the side walls of the lock were 40 ft. long and about 30 ft. high, and were built of 3-in. plank planed one side to even thicknesses. These forms were hung from a traveler 30 ft. high and 40 ft. long, running in advance of the movable derrick on the same rails.

The specifications provided that the lock should be built in sections not exceeding 40 ft. in length, and the ends of the sections were to have an offset or projection 6 in. in width, to form a water-stop. The ends of these sections were covered with two layers of tar paper applied with a hot mixture of coal-tar pitch, which was first spread over the surface of the concrete, then between the layers of tar paper, and finally over the entire surface of the tar paper joint.

The proper mixture and thickness to use for facing the side walls required considerable attention, and experiments were made to determine what proportions made the most impermeable concrete. From their results and from information obtained elsewhere, it was decided to use a 6-in. layer of 1: 1: 2 concrete for the facing. This was changed to a 1: 3 mortar, after the results of further experiments were known. This facing was carried up with the other concrete for the side walls, the 6-in. space being maintained by a steel diaphragm 12 in. high and about 10 ft. long, with spacers 6 in. long at each end and one in the middle to keep a uniform distance from the forms. As soon as the facing was placed, the diaphragm was removed and the mortar and backing spaded together to make sure of a good bond, and strips of No. 16 gauge, 3-in. mesh, expanded metal, 12 in. wide, were placed horizontally in the soft concrete 1 to 2 ft. apart, in order to prevent the facing from separating from the main portion of the wall.

A Private Car Service for disposing of ashes and for hauling coal from Lake Michigan to its plant at West Allis, Wis., has been undertaken by the Allis-Chalmers Co. All-steel bottom-dumping coal cars and side-dumping ash cars of 50 tons capacity have been placed in service on the company's private tracks. The coal cars are loaded direct from vessels at the docks on Lake Michigan, and the ashes are used for filling and ballast.

The President's Message on Hydraulic Engineering Works.

In his speech at Memphis on Oct. 4, President Roosevelt took occasion to state the views of the administration concerning the improvement of the hydraulic resources of the country. On that day the National Waterways Convention, attended by the governors of sixteen States and by many men prominent in public affairs, held its first session. In his introductory remarks the President asserted that the Mississippi Valley is better adapted to the development of inland navigation than any other valley in either hemisphere, for there are 12,000 miles of waterway now more or less fully navigable, and the conditions are so favorable that it will be easy to increase the extent of navigable waterways to almost any required degree by canalization. Early in our industrial history this valley was the seat of the largest development of inland navigation in the United States, and the President stated that the first steamboat west of the Alleghenies was built by a Roosevelt, his great-grandfather's brother, in 1811, for the New Orleans trade, and in that year made the trip from Pittsburg to New Orleans. But from various causes river and canal transportation declined all over the United States as the railroad systems came to their full development. It is our business to see that the decline is not permanent, and it is of interest to remember that nearly a century ago President Madison advocated the canalization of the Mississippi.

The great variety of natural resources and the extent of the manufacturing interests in the Valley render its welfare a matter of national concern, and the Mississippi River and its tributaries ought therefore to be utilized to their utmost. Facility of cheap transportation is an essential in our modern civilization, and we cannot afford any longer to neglect the great highways which nature has provided for us. These natural highways, the waterways, can never be monopolized by any corporation. They belong to all the people, and it is in the power of no one to take them away. Wherever a navigable river runs beside railroads the problem of regulating the rates on the railroads becomes far easier, because river regulation is rate regulation. When the water rate sinks, the land rate cannot be kept at an excessive height. Therefore, it is of national importance to develop these streams as highways to the fullest extent which is genuinely profitable. Year by year transportation problems become more acute, and the time has come when the rivers really fit to serve as arteries of trade should be provided with channels deep enough and wide enough to make the investment of the necessary money profitable to the public. The national government should undertake this work. Where the immediately abutting land is markedly benefited, and this benefit can be definitely localized, the President hoped that there will be careful investigation to see whether some way can be devised by which the immediate beneficiaries may pay a portion of the expenses—as is now the custom as regards certain classes of improvements in our municipalities; and measures should be taken to secure from the localities specially benefited proper terminal facilities.

We should act on the same principle in improving our rivers that we should follow in improving our harbors. The great harbors are of consequence not merely to the immediate localities, but to immense stretches of country, and the same is true of the great rivers. It is these great rivers and great harbors the improvement of which is of primary national interest. The main streams should be improved to the highest practical degree of efficiency before improvements are attempted on the branches, and work should be undertaken only when completion is in sight within a reasonable time, so that assured results may be gained and the communities affected depend upon the improvements. Moreover, as an incident in caring for the river so that it may become an efficient channel of transportation, the United States government should do its full part in levee building, which, in the lower reaches of the river, will not only give a channel for commerce, but will also give protection to the adjacent bottom lands.

Immense sums have already been spent upon the Mississippi by the states and the nation, yet much of it remains practically unusued for commerce. The reasons for this fact are many. One is that the work done by the national government at least has not been based upon a definite and continuous plan. Appropriations by Congress, instead of assuring the steady progress and timely completion of each piece of work, as it was undertaken, have been irregular and uncertain. As a direct consequence, far-reaching plans have been discouraged and continuity in execution has been made impossible. It is altogether unlikely that better results will be obtained so long as the method is followed of making partial appropriations at irregular intervals for works, which should never be undertaken until it is certain that they can be carried to completion within a definite and reasonable time. Planned and orderly development is essential to the best use of every natural resource, and to none more than to the best use of our inland waterways. In the case of the waterways it has been conspicuously absent. Because such foresight was lacking the interests of our rivers have been in fact overlooked, in spite of the immense sums spent upon them. It is evident that their most urgent need is a far-sighted and comprehensive plan, dealing not with navigation alone, nor with irrigation alone, but considering our inland waterways as a whole, and with reference to every use to which they can be put. The central motive of such a plan should be to get from the streams of the United States not only the fullest but also the most permanent service they are capable of rendering to the nation as a whole.

The industries developed under the stimulus of the railroads are for the most part permanent industries, and therefore they form the basis of future development. But the railroads have shown that they alone cannot meet the demands of the country for transportation, and where this is true the rivers should begin to supplement the railroads, to the benefit of both, by relieving them of certain of the less profitable classes of freight. The more farseeing railroad men realize this fact, and many of them have become earnest advocates of the improvement of the Mississippi, so that it may become a sort of inland seaboard, extending from the Gulf far into the interior, and the President hopes ultimately to the Great Lakes. An investigation of the proposed Lakes-to-the-Gulf deep waterway is now in progress under an appropriation of the last Congress. We shall await its results with the keenest interest. The decision is obviously of capital importance to our internal development and scarcely less so in relation to external commerce.

This is but one of the many projects which it is time to consider, although a most important one. Plans for the improvement of our inland navigation may fairly begin with our greatest river and its chief tributaries, but they cannot end there. The lands which the Columbia drains include a vast area of rich grain fields and fruit lands, much of which is not easily reached by railways. The removal of obstructions in the Columbia and its chief tributaries would open to navigation and inexpensive freight transportation fully two thousand miles of channel. The Sacramento and San Joaquin rivers with their tidal openings into San Francisco Bay are partly navigable now. Their navigation should be maintained and improved, so as to open the marvelously rich valley of California to inexpensive traffic, in order to facilitate both rate regulation and the control of the waters for other purposes. And many other rivers of the United States demand improvement, so as better to meet the requirements of increasing production from the soil, increasing manufacture, and a rapidly growing population.

While thus the improvement of inland navigation is a vital problem, there are other questions of no less consequence connected with our waterways. One of these relates to the purity of waters used for the supply of towns and cities, to the prevention of pollution by manufacturing and other industries, and to the protection of drainage areas from soil wash through forest covering or judicious cultivation. With our constantly increasing population this question becomes more and more pressing, because the health and safety of great bodies of citizens are directly involved.

Another important group of questions concerns the irrigation of arid lands, the prevention of floods and the reclamation of swamps. Already many thousands of homes have been established on the arid regions, and the population and wealth of seventeen states and territories have been largely increased through irrigation. Yet this means of national development is still in its infancy, and it will doubtless long continue to multiply homes and increase the productiveness and power of the nation. The reclamation of overflow lands and marshes, both in the interior and along the coasts, has already been carried on with admirable results, but in this field, too, scarcely more than a good beginning has yet been made. Still another fundamentally important question is that of water power. Its significance in the future development of our whole country, and especially of the West, is only just beginning to be understood. The plan of the city of Los Angeles, for example, to bring water for its use a distance of nearly 250 miles—perhaps the boldest project of the kind in modern times—promises not only to achieve its purpose, but in addition to produce a water power sufficiently valuable to pay large interest on the investment of over $23,000,000.

Hitherto such opportunities for using water to double purpose have not always been seized. Thus it has recently been shown that water enough is flowing unused over government dams, built to improve navigation, to produce many hundreds of thousands of horsepower. It is computed that the annual value of the available but unused water power in the United States exceeds the annual value of the products of all our mines. Furthermore, it is calculated that under judicious handling the power of our streams may be made to pay for all the works required for the complete development and control of our inland waterways.

Forests are the most effective preventers of floods, especially when they grow on the higher mountain slopes. The national forest policy, inaugurated primarily to avert or mitigate the timber famine which is now beginning to be felt, has been effective also in securing partial control of floods by retarding the run-off and checking the erosion of the higher slopes within the national forests. Still the loss from soil wash is enormous. It is computed that one-fifth of a cubic mile in volume, or one billion tons in weight, of the richest soil matter of the United States, is annually gathered in storm rivulets, washed into the rivers and borne into the sea. The loss to the farmer is in effect a tax greater than all other land taxes combined, and one yielding absolutely no return. The Department of Agriculture is now devising and testing means to check this enormous waste through improved methods of agriculture and forest management.

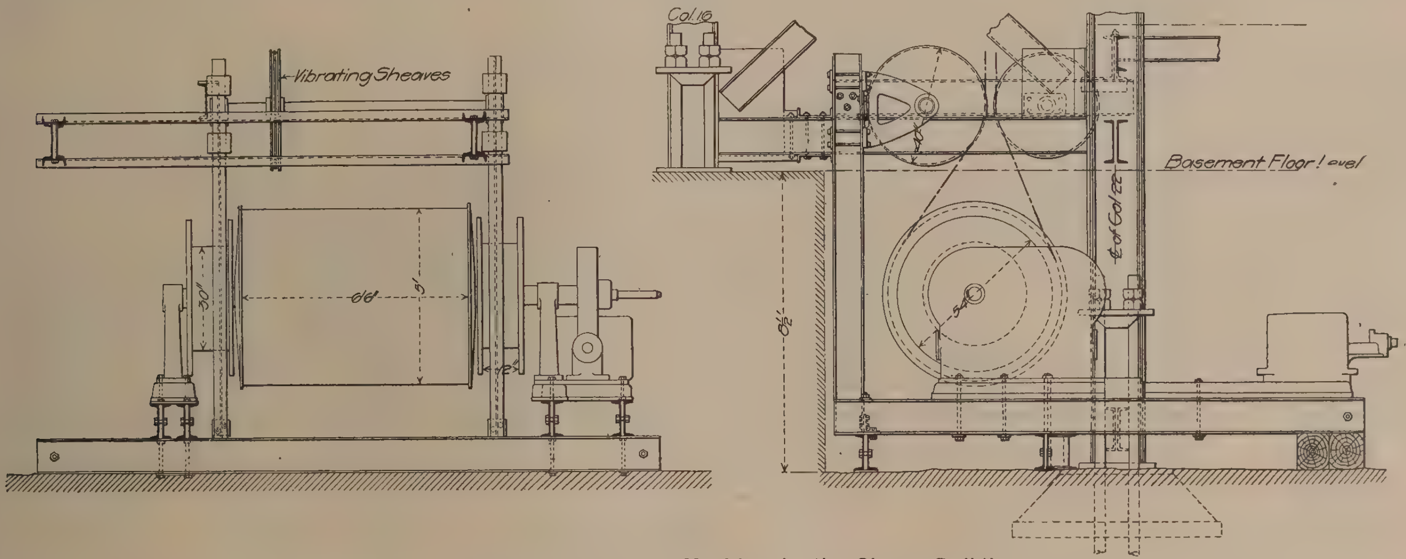
Citizens of all portions of the country are coming to realize that, however important the improvement of navigation may be, it is only one of many ends to be kept in view. The demand for navigation is hardly more pressing than the demands for reclaiming lands by irrigation in the arid regions and by drainage in the humid lowlands or for utilizing the water power now running to waste or for purifying the waters so as to reduce or remove the tax of soil waste, to promote manufactures and safeguard life. It is the part of wisdom to adopt not a jumble of unrelated plans, but a single comprehensive scheme for meeting all the demands so far as possible at the same time and by the same means. This is the reason why the Inland Waterways Commission was created in March last, largely in response to petitions from citizens of the interior, including many of the members of this congress. Broad instructions were given to the commission in accordance with this general policy that no plan should be prepared for the use of any stream for a single purpose without carefully considering, and so far as practicable actually providing for, the use of that stream for every other purpose. Plans for navigation and power should provide with special care for sites and terminals not only for the immediate present but also for the future.

The conservation of natural resources is the fundamental problem. Unless we solve that problem it will avail us little to solve all others. To solve it the whole nation must undertake the task through their organizations and associations, through the men whom they have made specially responsible for the welfare of the several States, and finally through Congress and the Executive. As a preliminary step the Inland Waterways Commission has decided, with the President's full approval, to call a conference on the conservation of natural resources, including, of course, the streams, to meet in Washington during the coming winter. This conference ought to be among the most important gatherings in our history, for none have had a more vital question to consider.

Steel Shot for Drill Points is now being made by spraying molten steel into cold water. The shot is extremely hard and in some formations can be used instead of diamonds.

Temporary Elevators for the Erection of the Singer Building Tower.

An unusual temporary elevator installation is in use during the erection of the 42-story tower of the new Singer Building at Broadway and Liberty street, New York City, as a precautionary measure for the safety of the workmen. Owing to the height of the structure and the incentive that usually exists in the construction of tall steel buildings to operate the material hoists at very high speed, it was here thought desirable to provide independent means of transportation for the workmen to and from the upper floor levels and thus free the material hoists from passenger duty. Accordingly a special elevator equipment has been installed by Mr. Ernest E. Flagg, the architect. It is of the electrically operated drum type, with provisions for raising the head-works from time to time and increasing the height of rise as the height of the structure increases. The equipment is, however, complete in every particular, with all the governing and safety appliances used in the best electric elevator installations, and is unique as one of the most effective measures taken for the safety of workmen in tall building construction, being the first installation of a complete elevator equipment solely for this purpose. The details of this tower extension of the Singer Building, and the many interesting features in its construction, have been described in a number of recent articles in this journal.



Details of Temporary Elevator Machine in the Singer Building.

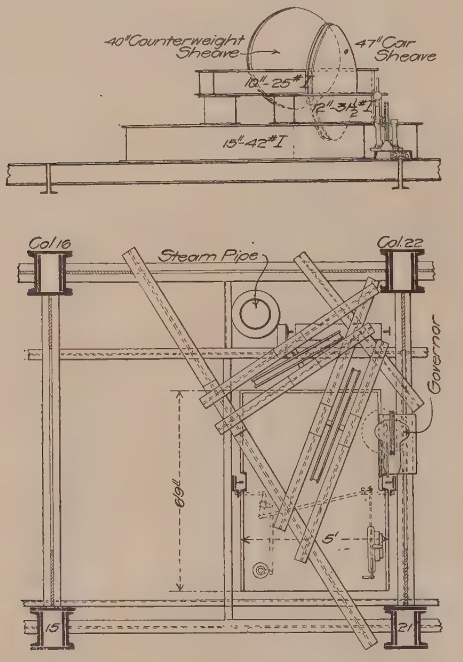
One of the factors that has favored the use of the material hoist for the accommodation of laborers traveling to and from upper floors of buildings during construction is the facility with which the head-works may be raised from floor to floor as the structure increases in height. The upper works generally consist of nothing more than a sheave, supported upon a temporary framework, which may be raised from floor to floor as required, while the necessary additional cable is merely paid out from the drum of the hoisting engine. It is rightly considered as a temporary feature of the construction equipment and is used for passenger travel, with no further precautions for safety than increased vigilance on the part of the engineer operating the hoist, no safety appliances being generally used, as is required on approved elevator installations. In the Singer Building, however, the great height of rise, nearly 550 ft., rendered this mode of travel more than ordinarily hazardous, as there exists a strong tendency to operate the hoisting cars at too high rates of speed on the long descents, and accordingly it was the desire of the owners and architects to provide something better.

In a study of these conditions by the Otis Elevator Co., of New York, a modification of the standard drum electric elevator equipment, which meets with all the requirements of a temporary installation and in addition offers the advantages of the safety of the approved electric elevator apparatus, was suggested, and a contract was awarded to this company to install such an equipment for use during the construction of the building. It was required to be adjustable for seven different heights of rise as the erection of the structure proceeds, top landings to be made at the 10th, 15th, 20th, 25th, 30th, 35th and 40th floors, respectively, while the equipment must be removed entirely upon completion of the building construction, and the installation of the final traction type of elevator equipment which will be used there.

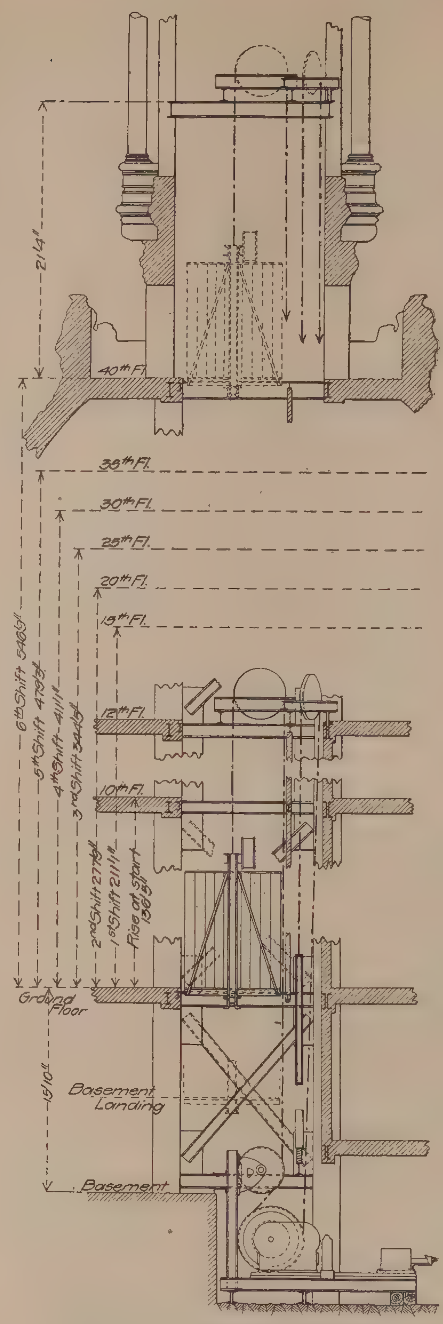
The electric drum type was selected as the most convenient, with respect to motive power, electric current for its operation being available from the 220-volt Edison street mains, which had been brought into the building for lighting and hoisting purposes, and as the maximum height of rise required, 546 ft. 9 in., is attainable by the use of a large drum. The special features necessary in the installation were, therefore, an extra size of drum to provide for the high rise, some means of storing the surplus cable while operating initially with the shorter distances of travel, and a means of readily transferring the headworks and the top limit mechanisms to the upper levels as it becomes necessary to increase the height of rise. A drum 5 ft. in diameter by 6½ ft. in length was chosen, with special mountings, providing for 12-in. reels between either end of the drum and the drum bearings, which served to carry the surplus cable for both car and counterweight before it was paid out for increased height of rise. The mountings are otherwise of the usual type of the Otis electric drum machine, consisting of the usual double worm-gear drive at one end, to which the driving motor is directly attached, but, owing to the temporary character of the installation, no permanent sub-base was used, the whole machine being mounted on 12-in. channels, rigidly bolted together, as shown in the accompanying details of the machine as installed.

The frame carrying the machine consists of two pairs of longitudinal channels for foundation beams, which are, to withstand the lifting effort of the car and counterweight, shored down from the wind-bracing members of the tower framework immediately above. Supported upon these beams are cross members, consisting of two pairs of channels for both the drum bearing and the worm-gear drive, and, at a distance of about 8 ft. above, a lighter auxiliary framework, which carries the shafts for the vibrating sheaves which guide the counterweight and car cables on and off the drum. The upper frame construction was simplified somewhat by attaching the members to the framework of the building, but the entire framework is firmly anchored to the foundation beams throughout. Considerable difficulty was experienced in locating the machine in the space at the foot of the elevator shaft, owing to limited room between a retaining wall and the adjacent building columns; it was, however, thought advisable to utilize one of the permanent elevator hatches for the temporary car, and this was accomplished by locating the drum in the 7-ft. space available between the columns and the retaining wall, allowing the motor and driving gear to project beyond the columns at one end.

The overhead gear was rendered easily removable by a special design of supporting beams for the car and counterweight sheaves, which are bolted together and so arranged as to be very easily detached when it is necessary to remove them. This construction consists of two 15-in. I-beams, arranged diagonally across the hatch for foundation members, upon which are two 12-in. I-beams, so placed as to locate the car sheaves properly. Upon one of the latter beams and a block on the outer 15-in. beam two short 10-in. I-beams are placed to carry the counterweight sheave. Owing to the use of one of the permanent elevator hatches, it was arranged to make use of car and counterweight guides available for the future permanent elevator installation. Two complete sets of this overhead framework were provided to facilitate the work of changing the car travel to a higher rise, enabling one set to be erected without sheaves in the desired new position, and the other set to be removed after the cables and sheaves have been raised to the upper set of beams. Special clamps were devised for bolting the beams firmly in position, which can also be readily released for their removal. Other features due to the removal of the overhead gear are the governor and the upper limit stops of the control system; these are in both cases mounted on special frames, which are merely bolted in position at each of the top landings, and thence removed simultaneously with the overhead gear. For the governor rope not paid out a 12-in. reel, 2½ ft. in diameter, is mounted on top of the car adjacent to the governor rope fastening, so that when increased car travel is desired the rope is unclamped at this fastening and paid out to the new length desired.



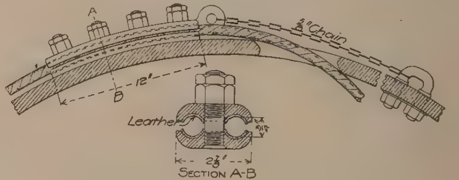
Details of Temporary Overhead Work.



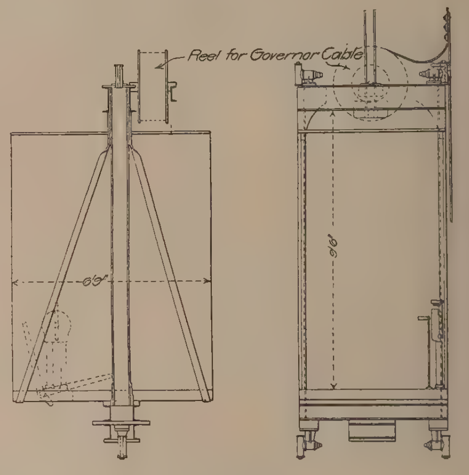
Rises of the Temporary Elevator.

The arrangement for storing the surplus rope until paid out for the higher distances of travel is, as above stated, narrow wooden reels mounted on the drum shaft between either end of the drum and the bearings, one of which is for the ropes leading to the car and the other for those to the counterweight. The reels are 12 in. in width and 4½ ft. in extreme diameter, or considerably less than that of the main drum, and the cables are fed out from them to the space inside the drum, and thence through a hole in the outer face to a special rope grip, by means of which it is anchored to the face of the drum. The rope grip is a forged clamp, with longitudinal leather-faced openings for the cables, and grips the two for a length of about 12 in., as shown in the accompanying detail, just after they pass through the hole in the face of the drum. Thus, in lengthening the rope for an increased car travel it is only necessary to loosen the bolts of the clamp, and after unfastening the reels pay through the required amount of additional cable, which is then clamped in the new position. The rope grips are fastened to the face of the drum in either case by a ⅝-in. chain about 20 in. in length, which extends from an eye in one end of the clamp to a U-bolt chain connection bolted to the drum.

The driving mechanism of the elevator machine is the gear of a standard No. 5 Otis double-screw drum machine, direct-connected to a No. 6½ Otis bipolar motor, which is wound for 220-volt direct current, so as to be operated from the Edison street service. The gear is designed for a regular operating speed of 400 ft. per minute, at which the car has a capacity of 2,000 lb., but for the purpose of lifting very heavy weights a back gear attachment has been added to the regular gear, which is readily thrown in by disconnecting a flange and shifting a pair of gears. This back gear has a ratio of 9 to 1 and facilitates raising the parts of the new traction elevator equipments which are to be installed in this building, an arrangement having been made by the Otis Co. in installing this temporary elevator to utilize it for this purpose. The machine is, for simplicity, operated with two ¾-in. ropes for both car and counterweight, instead of a larger number of smaller ropes, these sizes offering sufficient capacity for the service to be carried. The machine is controlled through one of the Otis magnetic controllers similar to those used with the traction machines.



Rope Fastening on Drum.



Details of Elevator Car.

A 150-Ton Crane of unusual construction has been installed at Birkenhead, opposite Liverpool, England, for the handling of great weights into vessels alongside the wharf. It consists of a special 3-footed supporting framework, which rises about 60 ft. above the dock level and is enlarged at the top to carry a revolving derrick structure with an overhanging jib. The latter is pivoted on a step bearing within the lower part of the suporting frame, and bears at the top against a pressure ring that withstands the thrust of the overhang. The jib has an extreme overhang of 88 ft. 8 in., and at the end carries an auxiliary hoisting gear of 50 tons capacity. The main gear, of 150 tons capacity, has a radius of action of 28 ft. A peculiar feature of the derrick is the use of continuous current power for the operation of the hoisting motors.

Single-Phase Electric Motive Power on the Rochester Division of the Erie Railroad.

By W. N. Smith.

One of the most important electric railway developments of the present year is the change from steam to electric motive power on a portion of the Rochester Division of the Erie Railroad, which took place on June 18, 1907. This is the first installation of a single-phase alternating system of electrical motive power upon a steam railroad, to go into commercial operation.

Four-Car Electric Train on the Rochester Division of the Erie Railroad.

The Erie electrification can justly claim the priority of application of several important features which are of interest in connection with the discussion now prevailing upon systems best suited for steam railroad electrification. This line was the first in this country to operate electric cars on the single-phase system over the tracks of an operating steam railroad; the first in this country to use 11,000 volts working pressure commercially on a trolley, and the first instance of a single-phase traction system receiving power from a 60,000-volt transmission line. All of the construction described below, except that of the 60,000-volt power transmission line and the car bodies and trucks, was designed, executed and placed in operative condition by Westinghouse, Church, Kerr & Co., engineers.

The section of track equipped is 34 miles long, extending from Rochester, over the main line of the Rochester Division, to Avon, a distance of about 19 miles, thence 15 miles over the Mt. Morris Branch. The railroad is entirely single-track, with sidings at way stations, averaging 3 to 4 miles apart. The grades are light, and the curvature for the most part quite easy, the line being relatively quite straight.

The track was originally laid with 68-lb. rails, but was relaid with 80-lb. rail, taken from another division just prior to electrification. The roadbed is ballasted with gravel, and the joints are of the Weber type. A single No. 00 protected rail bond is applied to each rail joint under the plate, one of the advantages of the high-tension single-phase system being that the relatively small current combined with the high impedance of the main circuit renders it unnecessary to resort to heavy bonding.

The line crosses a number of bridges, the longest one, that over the Genesee River, about 1½ miles south of Rochester, being 780 ft. long and comprising seven spans. There are also through truss bridges at Rush, and at Canaseraugo Creek, near Mt. Morris, and a stone arch bridge over Conesus Creek, a short distance south of Avon.

The electric service is devoted solely to passenger traffic, which is of the local interurban type. The freight service is handled exclusively by steam as heretofore, as are also the through trains operating between Rochester and Corning over the main line of the Rochester Division, a distance of about 94 miles. The steam service between Rochester and Mt. Morris originally comprised three round trips daily. The principal villages served are Avon, Geneseo and Mt. Morris the other regular way stations being little else than cross-road stops. The population is entirely agricultural, and the Genesee Valley traversed by this line is probably one of the most beautiful and prosperous farming regions of New York State. Instead of three round trips per day, the electric service has introduced six complete round trips between Rochester and Mt. Morris, and three more between Avon and Mt. Morris.

Power Supply.—The power is generated at Niagara Falls, in the plant of the Ontario Power Co., and is transmitted at 60,000 volts, three-phase, over the lines of the Niagara, Lockport & Ontario Power Co. The Iroquois Construction Co. built a branch line from Mortimer, a little over 4 miles south of Rochester, to Avon, locating it upon the Erie R. R. right of way for nearly the whole distance. The pole construction used upon this branch transmission line is of the A-frame type, using two 40-ft. cypress poles, set abreast of each other, and inclined so that their tops are framed together, the butts being joined by horizontal plank braces underground. The cross-arms consist of two 3½ x 6-in. timbers, 8 ft. long. The insular pins are of cast steel, one being placed at the apex of the A-frame, and the other two bolted near the extremities of the cross-arms, so that there is an equilateral spacing of 7 ft. between each of the three wires. The insulator pins are grounded by copper wire. The neutral of the transmission system is grounded at the power station through a resistance. Lightning protection of the horn arrester type has been installed at every fifth pole. The conductors are of No. 4, hard-drawn, stranded copper cable. The standard length of span between poles is 220 ft., which is shortened at curves where necessary. When crossing over the tracks of the Erie, or other railroads, recourse is had to a special construction of No. 0 copper cables carried on steel towers, so reinforced by guys that it is impossible for a failure of the line to result in dropping the conductors across railroad tracks.

Sub-Station Building.—The sub-station building is located in the Y formed by the railroad tracks at Avon, and together with the car shed, is adjacent to the roundhouse and division repair shop. The walls of the building are of brick, resting upon solid concrete foundations, the roof and floors being of reinforced concrete. The floors are supported upon steel beams, but the roof beams are of reinforced concrete, like the slabs which they support.

In the basement of the building are located one of the transformer oil tanks and the oil pump. The main floor is divided into three rooms, the main transformer room being 43 x 17 ft., and extending the full height of the structure to allow room for the high-tension bus-bars, which are carried over the transformers. The remaining space on the main floor is divided into a high-tension room (through which the 60,000-volt wires enter, and which is the location of the high-tension circuit breakers, 16 ft. 8 in. by 19 ft. 8 in.) and the operating room, which is 19 ft. 8 in. by 24 ft., where are located all the 11,000-volt switching apparatus and the measuring instruments. Directly over the operating room is a mezzanine floor, reached by an iron staircase, in which are located the 11,000-volt lightning arresters, the 60,000-volt choke coils, and the 60,000-volt series coils. The high-tension connections enter through the high-tension room, which runs from floor to floor, and pass through the choke coils and series coil, on the mezzanine floor, and then turn through a wide opening in the wall to the 60,000-volt bus-bars, which are located in the upper portion of the transformer room.

There is space in the transformer room for another transformer of the same size and there is also space in the high-tension room for an oil-insulated circuit breaker should it ever be decided necessary. The interior is painted with cold-water paint of the same light green shade that is commonly used by the Erie R. R. for interior finish.

The interior lighting equipment consists of 47 16-c.-p. incandescent lamps. Heat is supplied by a simple system of Colonial wall-type steam radiators, supplied by steam from the locomotive roundhouse.

Sub-Station Equipment.—The transmission line terminates at the lightning arrester yard in the rear of the sub-station. The arrangement of the 60,000-volt lightning arresters consists of three horn gaps, arranged one behind the other, on each of the three conductors, the first gap being 4¾ in. across, the second 5, and the third 6 in. A concrete column is in series with the first gap, an electrolytic arrester in series with the second and a 5-ft. fuse of No. 18 copper wire in series with the third, that is to say, between one horn and the ground. Both horns of each gap are of ½-in. round iron. Between the line and the first arrester there is a hook-type knife switch, and between the last arrester and the lead into the sub-station, there is a No. 18 copper wire fuse, in each conductor, placed horizontally upon a structure especially devised for it on top of a pole. These fuses are enclosed in wooden tubes about 5 ft. long, wrapped with torpedo twine. The entire arrangement of lightning arrester gaps, fuses and switches is mounted upon eighteen chestnut poles; and a suitable elevated platform, railed off and fitted with a gate to keep out trespassers, affords means of access to the apparatus when attention is required.

The three high-tension conductors enter the sub-station through glass disks held in 36-in. tile, set in the upper portion of the rear wall of the sub-station.

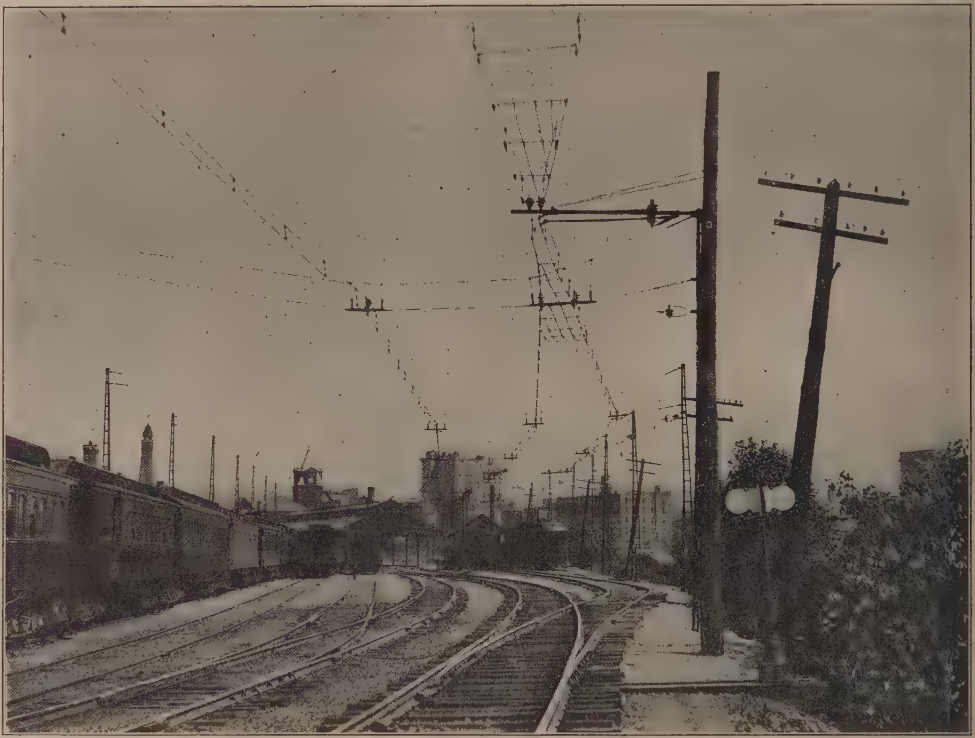
Within the sub-station, the wires first pass through three 60,000-volt stick-type circuit breakers, mounted directly inside of the rear wall. Thence, over bare copper conductors to the three oil-insulated choke coils, situated on the mezzanine floor, thence to three oil-insulated series transformers, also on the mezzanine floor, from which connections are taken to the power-measuring instruments in the operating room. The main connections finally terminate upon a set of copper bus-bars in the transformer room, which are run upon poreclain insulators mounted on wooden cross-arms and placed at a convenient height directly over the line of transformers.

The 60,000-volt three-phase current is rendered available for single-phase distribution by means of three transformers of the Westinghouse oil-insulated water-cooled type, each of 750 kw. capacity. For the present installation, two transformers only are used at one time, the third being a spare. The high-tension connections are such that in case of one transformer failing while in service, its connections can quickly be taken off the bus-bars, and put on the spare transformers. The transformer windings are fitted with taps enabling the three-phase to two-phase "Scott connection" to be used. The low-tension windings can be so connected that either 11,000 or 22,000 volts can be obtained, so that in case it should ever be desired to transmit railway current for an extension of 40 or 50 miles to another sub-station it could readily be done without adding transformers to this equipment. The low-tension windings also have six taps, enabling relatively small variations to be made in the secondary voltage, if they should be necessary to suit operating conditions in the trolley line.

One end of each low-tension winding is directly grounded to the boiler iron case, which in turn is, by means of a No. 0000 stranded copper cable, directly connected to the track return circuit.

The transformer cases are made of boiler iron, and set on a square cast-iron base, which is in turn mounted on three pairs of wheels running upon an iron sub-base set in the concrete floor of the room. A track runs lengthwise of the room directly in front of the transformers, a transfer truck running upon it, upon the top of which there is another set of little wheels or rollers, which line up with those upon which the transformer cases are set. When it is desired to remove the windings from the transformer case, it is only necessary to disconnect the electrical, water and oil connections, roll the transformer off its sub-base and onto the truck, which is then pushed to the rear of the transformer room, where it comes directly under a 10-ton hand hoist, which is able to lift any part of the transformer that repairs make it necessary to handle.

Two cylindrical boiler-iron oil tanks are provided, each of slightly greater capacity than a single transformer. One is located in the basement directly under the transformer room, so that the oil from the transformer can readily be drained into it. The other is suspended from the concrete roof beams at the top of the transformer room, close to the side wall of the building, this being intended to act as a reservoir for distributing oil back into the transformer. The oil is pumped from the lower to the upper tank by means of a steam pump supplied from the boiler room in the adjacent division roundhouse, where steam is always available. From the upper tank oil is fed by gravity into either transformer. It is thus a simple matter to draw the oil from any transformer if its insulating qualities are found to have depreciated, and the rehydrating, filtering or purifying apparatus can readily be employed with the aid of the pump, and the supply returned again to storage. The oil piping is of iron throughout.



Overhead Construction in the Rochester Yard.

The water circulation is by gravity, the supply coming from the railroad company's water tank system, at the adjacent roundhouse, being pumped originally from the Genesee River about a mile distant. An artesian well had been opened on the premises, but the water was so strongly impregnated with sulphur and other impurities that it was thought best not to introduce it into the copper piping in the transformers, although the cost of such a supply would have been practically nothing.

There are three separate water-cooled coils in each transformer case, each controlled by its own valve, so that the amount of water may be controlled as found necessary under various conditions of load.

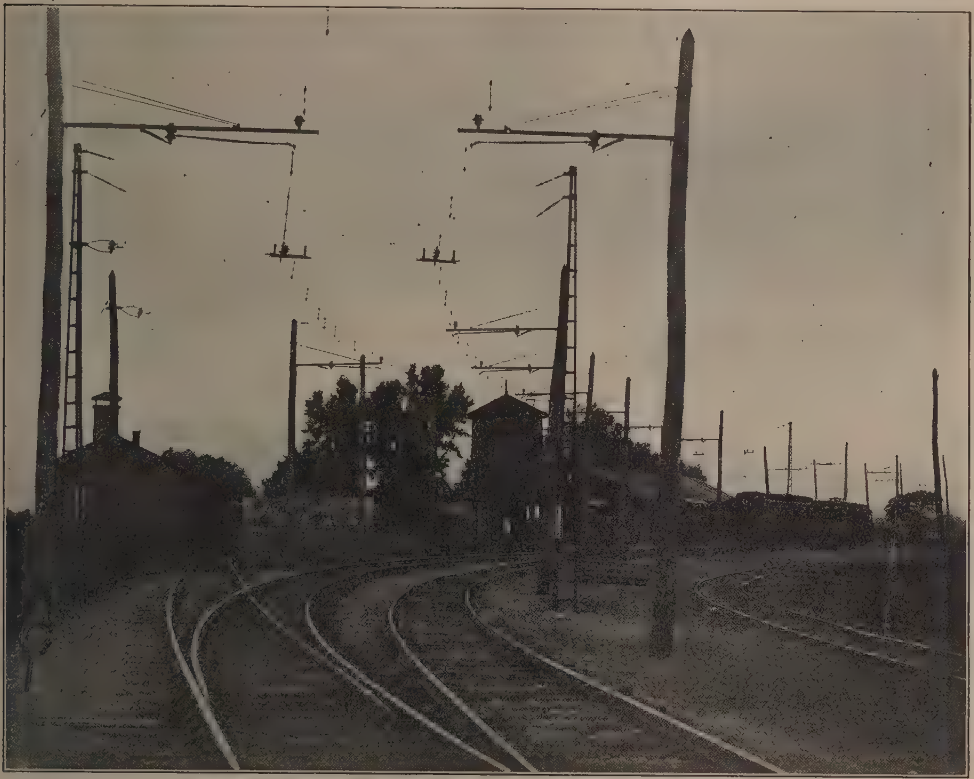
The necessary transformation from three-phase to two-phase fits in very well with the natural subdivision of the electrified line into two sections, one of which is about 19 miles in length, north of Avon, the other about 15 miles in length, being to the south of Avon. The connections were therefore laid out to operate such sections upon separate phases of the two-phase secondary system. Either the T or V connection can be used, the latter method being employed at present. Each one of the active transformers therefore feeds a separate section.

As mentioned above, one terminal of each single-phase, 11,000-volt transformer is grounded. The middle transformer of the three is ordinarily used as a spare, and the other low-tension lead from this transformer runs to the center of a double-throw switch, whose outside poles connect separately to two low-tension bus-bars. The ungrounded low-tension terminals of the other two transformers connect through single-pole switches, one to each of these bus-bars.

The low-tension bus-bars run along the wall of the operating room, and directly beneath them are three type-E Westinghouse automatic oil circuit-breakers, one on each of the two trolley feeders, the third breaker which is situated between the other two, being a spare. One pole of each of the three oil breakers is connected to the center pole of a double-throw hoop-type knife-switch, by means of which it is thrown upon either bus-bar. The other pole of the oil breaker runs directly to the feeder. The outgoing lead from the middle or spare circuit-breaker runs to the center pole of the double-throw hook-type switch, so that it can instantly be thrown upon either one of the feeders, should the breaker usually confronting that feeder be temporarily disabled. This system of connections is simple, compact and flexible, and has admirably fulfilled the conditions for which it is intended.

The outgoing 11,000-volt feeders run up to the mezzanine floor directly over the operating room, where they emerge from the building through perforated glass disks, set in 18-inch round tiles. Before emerging there are tapped to them two Westinghouse low-equivalent lightning arresters, set in brick compartments and reinforced by two electrolytic lightning arresters of the 11,000-volt type. A set of call bells is provided so that when the automatic breakers open, a bell is rung in the adjoining car-inspection shed. Also, if the temperature of any transformer runs above normal, a bell circuit connected to a thermometer in the top of the transformer tank is similarly made to operate. The station itself does not require the continuous presence of an attendant, which is needed in the case of a rotary converter sub-station. The working force is so organized that the car-repair men are always available for manipulating the sub-station circuit-breakers, and the cost of attendance is thereby reduced to a minimum.

Catenary Trolley Construction.—The overhead trolley construction is in many respects unique. It was the first of all catenary installations to operate regularly at 11,000 volts. There were very few precedents to follow; many of the details of the overhead work are entirely original, and nearly all of them were especially designed for this installation by the engineers who executed the work.



Overhead Construction, Mt. Morris Terminal.

The poles are of chestnut, averaging 25 in. in circumference at the top, and about 42 in. at the butt. Most of them are about 35 ft. long, but 40-ft. poles were used where the embankments were narrow and steep, and in span construction. Nearly all the construction is of the bracket type, except at the railroad yards at Rochester, Avon and Mt. Morris, and for some distance at Mortimer, where there is a siding on each side of the main track, which prevented the use of bracket construction there.

The poles are given about 12 in. rake. They are tamped with cobblestones, of which plenty were available from the coarse gravel with which the road is ballasted. The ground proved very deceptive as regards the nature of the digging, much water-bearing gravel and quicksand being encountered, and oil-barrels had to be resorted to in many instances, to prevent caving in of the holes during pole setting.

The brackets are of an entirely original design, each consisting of a 3 x 2½-in. tee, 10 ft. long, the heel of which is fastened to the pole by a pair of bent straps, the outer end being supported from the pole-top by two ⅝-in. steel truss rods, instead of the single rod commonly used for bracket work. The two rods are attached about 27 in. back from the outer end, and run one to each side of the pole, and are fastened there to a pole clamp devised for this work, which grips the top of the pole instead of requiring the bolt or truss rod to pass through it. In this way the timber of the pole is kept intact, and does not have a hole bored through it which will admit moisture and induce rot. The two truss rods are threaded at both ends, and at the upper end each one passes through a small iron casting which is in turn carried upon a bolt projecting out from the cast-iron portion of the pole clamp, like a trunion. The whole construction is extremely rigid, and is stronger and more conductive to a long life for the pole than any bracket hitherto used. Where necessary, at switches, extra long brackets are employed, being lengthened by splicing and an extra truss rod being attached by means of a clamp to the outer end of such a bracket and run to the extreme top of the pole.

The insulator pins are of malleable iron, of a type specially devised for this work. The lower portion of the pin was divided and fitted closely over the flanges of the tee bracket, being provided with a single ⅝-in. bolt by means of which the lower split portion of the pin is clamped securely against the bracket. The brackets and pins were furnished to the engineers' designs by the Electric Service Supplies Co.

The insulator is of R. Thomas & Sons manufacture, 6⅞ in. in diameter and 6 in. high, made in two parts, but of the three-petticoat type, and known as No. 3029. It was designed by the engineers especially for this installation. As most of the overhead work was done during the winter months, and had to be rushed, a quick-setting cement of litharge and glycerine was used in place of Portland cement, which not only permitted rapid work in construction, but obviated troubles due to the freezing of hydraulic cement while setting.

The insulator pins are ordinarily about 12 in. from the end of the bracket, but there is 27½ in. space between the end of the bracket and the point where the truss rods support it, which permits sufficient variation in location of insulator to meet most of the requirements in shifting the alignment of the trolley wire on curves.

The messenger wire is of "extra high strength" steel, furnished by the American Steel & Wire Co. It is of seven strands and is 7/16 in. in diameter. Joints are made by using the so-called "open" and "closed" cable sockets, the sockets being sweated on to the abutting ends of the cables and joined by a pin connection through the eyes of the sockets. The trolley wire is No. 000 B. & S grooved copper, the lengths being spliced with the usual type of soldered splicing sleeve.

The spans on the straight line track are 120 ft. in length, and as much shorter than this on curves as required by the radius of the curvature The maximum deflection from the center line of the track, on curves, is 7 in. each way. The catenary hangers were of the Electric Railway Equipment Co.'s drop-forged type, being modified by the engineers to suit the requirements. The messenger clip and the trolley clip are of the same type but grooved differently to accommodate their respective wires. They are joined by a ⅝-in. iron hanger-rod, with right-hand threads on each end, the longer rods being flattened in the middle to admit of bending them slightly, so as to conform to the divergence of the messenger and trolley wire near the ends of the spans. Both trolley and messenger ears are secured in position by jam nuts. This type of suspension was developed especially for this installation, and is so constructed that there is no possibility of parts coming loose and falling apart on account of vibration. It is also very quickly and easily adjustable on trolley wires. The hangers are spaced every 10 ft.

The steady strain rods are of treated wood of the Westinghouse Electric & Mfg. Co.'s make, and they are mounted at one side of the bracket instead of directly underneath, in order to give sufficient clearance for the pantagraph trolley on curves, where the super-elevation results in the tilting of the shoe from the horizontal.. Each steady strain rod is hinged to a spool type Thomas porcelain strain insulator, which is clamped to one side of the bracket in such a manner that the hinged end of the rod is almost at the elevation of the top of the tee bracket. The method of attaching the steady strain insulators to the bracket is such that they can readily be shifted along the bracket to follow up any change in alignment of the trolley wire that may be required by curvature or for any other reason. The clamps holding the steady strain insulators are of 3 x ⅜ in. bent iron. The spool type insulators are cemented on to pieces of ¾-in. pipe, through which passes the ⅝-in. eye-bolt by means of which they are attached to the bent irons. Steady strains are used only on curves and turnouts and were not found necessary on tangent track.

The tie wires are of No. 9 Extra BB, galvanized telegraph wire, because it was thought best not to make too rigid an attachment between the messenger wire and the insulator; so that if a bracket became detached from the pole for any reason, its weight and the shock of detachment would tear the wire clear from the messenger and allow the bracket to fall entirely away from the wire and reduce the chance of steam railroad trains colliding with it. An accident to the electrical equipment of a railway operating both steam and electric trains may shut down the electric service, but will not automatically place any check upon the steam service, so that accidents to steam trains must be guarded against, as a steam train might easily be wrecked by an obstruction which would automatically prevent power from being supplied to an electric train. This was one of the reasons for installing the system of "ground rods" from the brackets to the rails, which is carried out very consistently throughout the installation. Every bracket is grounded to the rail, so that an insulator failure will instantly throw off the power, as it will cause a complete metallic short-circuit. There is thus no danger of setting the wooden poles on fire, which would be possible if this precaution were not taken. The burning of a wooden pole would not of itself necessarily cripple the electric service, but it would be quite likely to cause an obstruction dangerous to the passage of steam trains which are, of course, independent of any disturbances on the electric motive-power system. Up to the present time, however, there have been no cases where the overhead construction has caused any obstruction to the passage of the steam traffic.

The ground rods consist of ⅜ x 1¼ in. flat steel, their upper and lower ends being bolted to track rail and bracket respectively.

The span construction is as nearly as possible similar to the bracket construction and uses the same type of pin and insulator. A piece of 3 x 2½-in. tee about 30 in. long is suspended from the span wire by hangers of galvanized strand cable, adjustable in length, and fastened to the span wire cable by specially designed clips, the construction forming a sort of stirrup upon which the pin and insulator are carried. The messenger wire rests upon the insulator just as in the case of regular bracket construction. This form is used, not only for spans where there is but one track, but also in the yards at Avon, and Rochester, where three or four parallel tracks are electrified. Span construction, in general, was only used where conditions absolutely required it.

The Rochester yard was a difficult piece of construction on account of the distance between supports (which reaches a maximum of 94 ft. where spanning seven tracks, four of which are electrified), and also on account of the uncertain nature of the soil which, on the river bank, is filled in with gravel and cinders. For these long spans, where it was impossible to use guys of the usual type (the river bank being on one side and the main highway which gives teams access for loading and unloading freight cars on the other side), it became necessary to use self-supporting span construction, and this was done by using the "Tripartite" type of steel pole, set in concrete. This type of pole being constructed of re-rolled Bessemer steel rails is less subject to rust and consequently more durable than any other available type of metal pole, and all of its surfaces are always open and easy of inspection. On account of the great tensile strength of the material, there is considerable saving in weight, and the fact that it was a standardized product enabled quicker delivery to be made than though special riveted poles of structural steel shapes had been specially designed for these locations. The span wires consist of the regular messenger cable fitted with cable sockets sweated on at each end, the same being fastened to turnbuckles and pole collars at the tops of the poles. There are two span cables at each pair of poles, the upper one being used to carry the weight, the lower one acting to steady the arrangement and also to act as a relay in case of an accident to the upper span. Similar construction was also used at Avon, where guying of side poles was not always possible.

A very simple type of pull-off was devised for curves in span construction, and it so happened that both the Rochester and Mt. Morris yards have considerable curvature. The pull-off consists simply of a spool-type insulator, with a piece of pipe cemented through the center, this pipe being slipped over the hanger spacing-rod joining the messenger and trolley clips, thus giving an insulating connection through which an ordinary pull-off cable can be attached to both messenger and trolley wires wherever required. The division of the horizontal pull between the messenger and trolley wire is easily adjusted to suit the conditions, by shifting the spool-type insulator up and down the spacing rod, by inserting longer or shorter nipples of pipe underneath it. In general, when near a span wire, the messenger cable is supported rigidly on its insulator and the trolley wire needs all the side pull; but in the middle of a span, the pull must be equally divided between messenger and trolley wire.

The presence of several through-truss bridges over streams, and two low bridges over the Erie right of way, necessitated the employment of special construction at these points, particularly at the bridge at Clarissa St., on the outskirts of Rochester. The original clearances here were so low that the road-bed had to be excavated and the track lowered about 2 ft., the minimum clearance between the rails and the trolley wire being finally 18 ft. The messenger is fastened to a horizontal spool-type insulator mounted at the center of a substantial piece of turned oak, which is long enough to carry two more similar insulators, one on either side of the center one.

The steel hangers reaching down from the overhead bridge structure carry the two side insulators, so there are always two insulators in series between the 11,000-volt messenger cable and the steel work of the bridge. These insulated supports are suspended at short intervals from the under side of the steel-work of the bridge and are further supplemented by the use of steady strains which prevent any side displacement of the trolley wire. The shortest sizes of hanger spacing rods are used in such places. Where the bridge truesses are high enough to permit it, an iron stirrup is employed like that used in span work, which carries the standard form of straight line insulator, and the regular type of catenary suspension is employed.

At either side of these overhead obstructions it was necessary to provide warnings for brakemen upon the tops of freight cars, as substitutes for the warnings of hanging pieces of rope previously used. They consist of the well-known type of horizontal, suspended, swinging wooden rod, mounted with its axis at an angle, so that it swings up as it is pushed to one side. The pantagraph trolley is fitted with a set of springs on each side, one of which strikes this warning sign a blow as it passes under and instantly throws it one side. The blow is struck upon a heavy leather strap held taut by a coil spring of steel wire in tension, the whole contrivence being fastened to the lower half of the pantagraph trolley mechanism so that it is at the right height for striking the warning sign. The swinging rod is mounted upon the pole by means of insulators, effectually preventing any leakage to the ground, even though a car might stand still directly under the sign and make contact with it for an indefinite length of time.

Nearly all the telephone and telegraph wires which cross over the 11,000-volt trolley wire have been put underground, particularly in the case of the leads composed of only a few wires, but where the line is crossed by heavy telephone trunk lines, they have been protected by the basket type of construction, so designed as to effectually prevent a broken telephone wire from falling across the messenger or trolley wire. This consists primarily of four galvanized steel cables stretched between opposite ends of two cross arms, one placed above and the other below the wires of the intersecting telephone line, and the four cables are joined by a basket-work of light strap-iron ribs placed at intervals of 3 to 4 feet across the whole span, forming the sides and the bottom of the cradle and effectually preventing a broken telephone wire from dropping any further. This construction was also followed in the case of an electric wire at Avon.

The telegraph department of the railroad company, in connection with the signal department, constructed a private telephone line of two copper wires between Rochester and Avon, with instruments at all signal towers and stations in the dispatcher's office, and at the sub-stations, and car shed, and master mechanic's office. This telephone system is run upon the trolley bracket poles, transposed every third pole, and has worked satisfactorily.

Lightning protection for high tension single-phase railway lines not having as yet been standardized, only a part of the line was equipped with line lightning arresters, which are of a swinging fuse gap type made by the Westinghouse Electric & Manufacturing Co. This type consists of a gap one side of which is connected directly to the trolley through a No. 4 copper wire, and the other side directly connected to the ground rod through a fuse enclosed in a tube which, while the fuse is intact, is maintained in an inclined position like a pendulum held back from its position of rest; but when the fuse is blown, a latch is released which allows the fuse tube to swing to a vertical position which shows conspicuously from the ground, and signifies to the patrolman that the fuse should be replaced. The fuse tube can then be lifted off the suspending lugs by a pair of insulating tongs made for the purpose, and the fuse renewed and replaced in a few moments.

On the other half of the line, lightning arresters were not installed. During the summer, two of the poles were struck by lightning, but the metal-work of the brackets and truss rods being entirely grounded, these poles were not damaged below the topmost point of attachment of the truss rods, which is generally not over 18 in. from the top of the pole. In a number of instances the lightning-arrester fuses have blown, but it is not known how many of them have blown simultaneously. Although the extent to which this type of arrester is fully protective is hardly established as yet, it can be stated that at no time since regular operation started has any injury to the car equipment resulted from lightning, though there were several severe storms during June and July.

The trolley line is divided into seven sections —one comprising the Rochester terminal, one the Avon yard, three sections in the main line between Rochester and Avon, and two sections south of Avon.

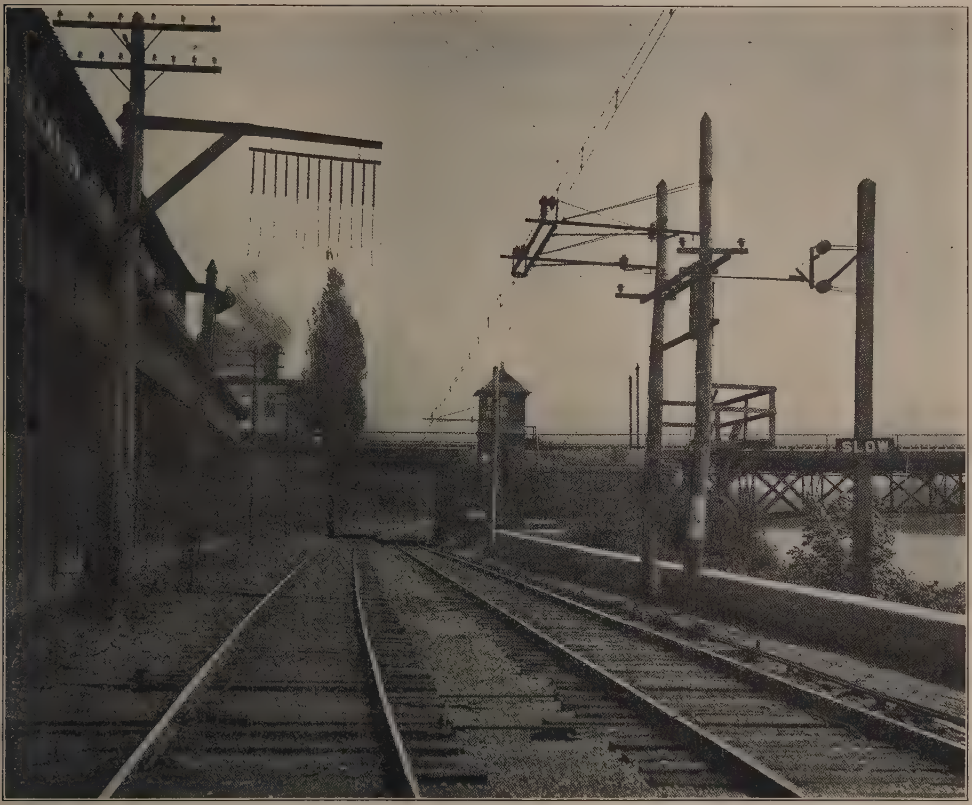
The sections are divided by trolley section insulators, made by the Westinghouse Electric & Manufacturing Co. They are of the overlapping type, made of impregnated wood, and are of sufficient length to insure insulation at 11,000 volts. Each section insulator is carried upon two brackets, mounted on poles spaced 10 ft. apart. As the trolley and messenger must both be completely insulated on opposite sides of the breaker, heavy strain insulators are introduced upon which the messenger is dead-ended, the two insulators being connected across the gap by a heavy steel rod. This entire combination is supported upon standard insulators mounted upon the regular brackets.

One of the breakers, that opposite the sub-station at Avon, is different from the above-mentioned type, in that it is not of the overlapping type, it being necessary to absolutely separate the two halves of the trolley line in order to utilize the separate phases of the trolley current of each half.

The only feeders necessary are those connecting the sub-station with the trolley on opposite sides of this section break. The principal object of cutting the trolley into additional sections is to facilitate the locating of line trouble.

The conditions of electric traction upon this line are such that no feeder is necessary besides the trolley wire, and consequently there is no necessity for feeding the sections separately. A jumper is therefore provided at each section insulator, in which is placed a hook-type knife switch that can be operated in case it is desired to cut that section out. Normally, however, the switches are closed, and the effect of the jumpers is to make the trolley wire continuous.

Another detail peculiar to the catenary type of trolley construction is the "deflector," a sort of mechanical fender placed in the angle formed by the intersecting trolley wires at switches. The deflector here used consists of four or five bars of flat steel, ½x¼ in., suspended by riveted hangers from crossbars spaced 5 ft. apart, which in turn rest on standard trolley clamps, fastened to the trolley wire. The particular advantage gained by this construction is that no extra tension is needed to keep the bars from sagging and getting crooked, this type of deflector being of minimum weight and entirely self-contained. They are placed in both angles of each switch. The object of the deflector is to prevent the end of the pantograph shoe, when traveling under either wire, from becoming hooked over the other.



Overhead Construction Showing Trolley Section Insulator, Rochester.

Cars.—The cars equipped with electric apparatus are six in number, and, together with their trucks, were furnished by the St. Louis Car Co. The electrical apparatus was installed upon the cars and trucks by the engineers at the railroad company's car shops in Buffalo, N. Y. The cars are 51 ft. 4 in. over bumpers, 43 ft. over corner posts and 29 ft. 4 in. between truck centers. They are 8 ft. 9 in. wide over sheathing and 13 ft. 8⅝ in. in height above the rail. Four of the six have two passenger compartments, the other two having a baggage compartment about 14 ft. long, and a smoking compartment, with six seats, besides the regular passenger compartment.

Each car is fitted with a 50-c. p. headlight at each end, on top of the hood, and it is also fitted with a gong, air whistle and with the standard train air signal used by the Erie R. R. The toilet is in the center of the car, adjacent to the partition between the compartments. The "Standard" steel type of platform buffer is used, and the regular M. C. B. coupling, air hose connections and safety chains are provided, so that the cars can couple up to any of the standard Erie rolling equipment.

There being an open space between the abutting vestibules when two motor cars are coupled together, due to the rounded and projecting buffer beams of the platforms, this opening being nearly 18 in. in width, which is wide enough to allow a person to fall between the cars, there were provided canvas curtains about 5 ft. high, with snaps attached, which enable them to be quickly stretched across the space, one on each side of the vestibule end door, so as to insure the safety of trainmen and passengers when walking from one car to another with the train in motion.

The trucks are both alike, wheel base being 6 ft. 8 in. The axles are 6½ in. diameter. The trucks are of the standard M. C. B. swing bolster type, with heavy framing. The brake shoes are inside hung.

The heating equipment consists of 32 of the Consolidated Car Heating Co.'s electric heaters of the truss plank type, and 450 watts capacity each, in the main portion of the car, and two "No. 192 M. S." heaters in each cab.

Electrical Equipment.—The electrical equipment of the cars consists of four No. 132-A Westinghouse single-phase railway motors, with a nominal rating of 100 h. p. each, the gear ratio being 20:63. The suspension is of the nose type, and solid gears are pressed upon the axles.

The control system is of the Westinghouse electro-pneumatic type and includes three distinct circuits, the high potential, the low potential and the control circuit.

The high potential circuit includes the pantograph trolley, line switch and the transformer. The pantograph trolley mechanism is operated by a pair of springs and by an air cylinder. The trolley is raised and held against the wire by means of springs against its own weight, and it is lowered by the application of air pressure to pistons working in cylinders that form part of its base. When down it is automatically locked, and the latch of this lock can only be withdrawn by applying air pressure to another small piston, which then unlocks the pantograph, allowing the springs to raise it. This trolley mechanism is so connected with the control circuit through the line relay that any interruption in the supply of high-tension current immediately causes the trolley to be lowered by applying the air to the main cylinders in the trolley base.

The line switch is equivalent to a main high-tension circuit breaker. It is opened and closed by air pressure, admitted by electrically operated valves. In case the supply of air is exhausted, as when the car has stood for some time unused, the line switch must first be held in mechanically by means of a handle provided for the purpose, until the air pump, which can then be thrown into operation, has compressed air to about 50 lb. pressure, which is enough to properly actuate the control system. To raise the trolley when there is no air pressure there is provided a small automobile tire pump, placed underneath one of the car seats, which is connected by a three-way cock into the trolley air piping system, and enables the air-operated trolley latch to be withdrawn and power obtained that will start the air compressor and set going the motor generator set, which is used for charging the storage battery and supplying current to the control circuit.

The transformer is of 200 k. w. capacity and is of the oil insulated type. It has three high-potential and eight low potential taps, the latter running from 300 down to 110 volts, at which latter pressure current is provided for heating, lighting and auxiliary purposes.

The high-tension wiring of the car is done mainly with varnished cambric cable, drawn through loricated iron conduit. A small amount of high-grade rubber cable is used, but it is thoroughly protected with varnished cambric tape wherever there is danger of a brush discharge to ground breaking down the insulation.

In the main low-potential circuit are the switch group, the preventive coils and the reverser. The switch group is a set of air-operated switches, controlled by magnet valves, all mounted in one frame. It is placed athwart the car as near as possible to the low-tension end of the main transformer. The switches of the group are all provided with interlocks, which automatically govern the connections in such a way that each switch of the group acts only when the current in the motors has reached a predetermined value, thus making acceleration automatic. Preventive coils are used across the terminals of some of the switches of the group, to prevent excessive current flowing at the instant of closing the switch. Each switch in the group is fitted with its own blow-out coil. There are two reverser switches actuated by air pressure, one for each pair of motors.

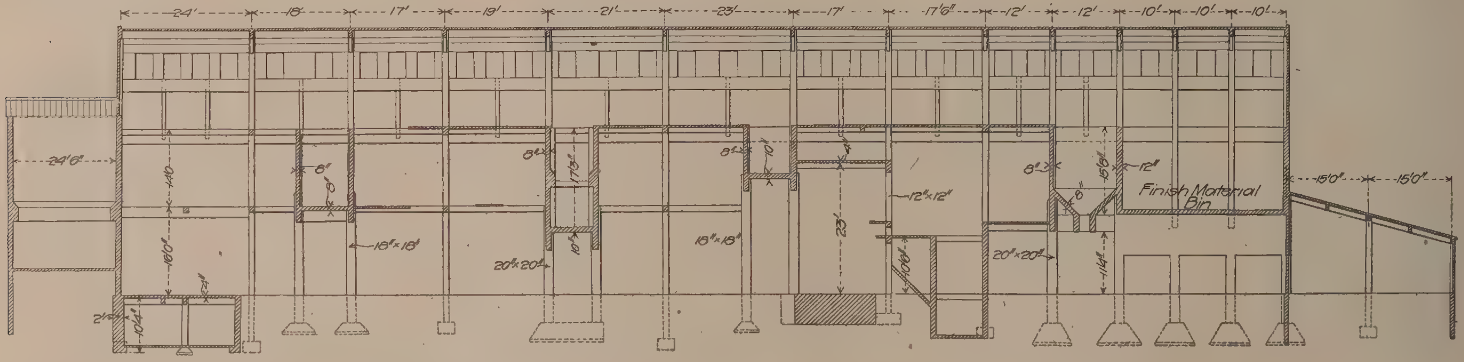
Current from the main motor circuit is led through the motor limit switch, which makes effective the functions of the interlocks on the switch group, and renders it impossible for the successive switches to be thrown in unless the limit switch is closed.

The control circuit includes a master controller in each vestibule, the train line wires and their connections to the valve magnets, and interlocks a storage battery supplying current for these wires, and a motor generator set, which is used either to charge the batteries or to actuate the control system. The master controller makes the proper connections, by means of which the 15-volt storage battery actuates the valve magnets which control the action of the air-operated main contactors in the switch group, and the reversers. The controller handle is normally held in a vertical central position by springs, unless it is moved to one of the running points by the motorman. When released from the grasp of the hand it flies to the vertical position, cutting off the power, and enabling the emergency application of the brakes by means of brake relay valve alongside of it. There are two holes in the face of the master controller, directly under the handle, and attached to the handle by means of a chain is a plug which may be inserted into either of these holes. The master controller is not operative unless this plug is pushed all the way into the lower hole, which closes the line switch connects the generator and battery, and puts the brake relay valve into circuit. This is the ordinary running position of the plug. In case the line switch is opened by an overload, which generally causes the trolley to be lowered, the plug is taken out of the lower hole and placed in the upper, which action immediately closes the line switch, releases the trolley and allows it to spring up against the wire. As soon as the power is thereby returned to the main circuit the plug is taken out of the upper hole and replaced in the lower one.

There is a push button upon each side of the bottom of the master controller case. That on the right-hand side is used for dropping the trolley and opening the line switch. When the button on the left-hand side is pressed the switch group is stepped up to the last, or high speed, notch and remains in that position until the handle of the controller has been returned to the off position.

There are four distinct notches on each side of the controller, the first corresponding to the coasting position with the power off, the others enabling such gradations of speed as may be desired. Reversal is effected by moving the controller handle to the opposite side of the center, or dead, point. If the controller stops on the dead point, as it will if released by the hand, it will immediately apply the brakes.

The motor-generator set is a compact machine of about 1/6 k. w., the motor being of the self-starting induction type, wound for 110 volts, the generator being normally of about 23 volts. It is placed under one of the seats in the car and is covered by a box with removable lid, so that it can easily be reached for such small attention as it requires. It is mounted upon rubber bushings, and runs so quietly that its presence in the car can hardly be detected.



Longitudinal Section of New Plaster Mill of the American Gypsum Co.

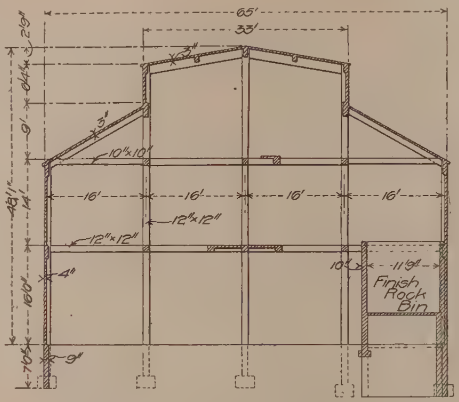
The storage battery consists of seven cells contained in a wooden box with handles, carried in an enclosed box underneath the car. No other auxiliary lines for any purpose are connected to the control circuit, in order to prevent it from being disabled by accidental grounds.

In one vestibule there is located in an asbestos-lined compartment, enclosed with steel doors, a slate switchboard panel, upon which are carried all the switches and fuses for the control of the battery and motor-generator set, the lighting circuits and heaters, and also the main connection from the low-tension side of the transformer to the auxiliaries.

The control circuit is fitted with junction boxes, branches running to receptacles at each of the four corners of the car directly under the end sills. The jumpers for connecting the cars and the receptacles are of the 12-point type, there being 12 wires in the main control circuit.

The low-tension wiring between the transformer and switch group and motors is all enclosed in a boxing of "Transite" to insure its protection against mechanical injury, as the inductive effect of heavy currents at low potentials renders the use of iron conduits impossible for this part of the wiring.

Operation.—The equipments above described were intended to be sufficient for operating single cars, with one stop per mile over the entire road, at an average schedule speed of 24 miles per hour, or to haul one trailer, making stops about 2½ miles apart, at the same schedule speed. The company has furnished shelters where the public highways cross the line, there being 22 of these flag stations, besides the regular intermediate way stations, at which steam trains stop, six in all, or a total of 28 stations at which electric cars may be required to stop. Practically the electric cars stop at all the regular way stations, but at only a portion of the flag stations. A single passenger coach is frequently attached to a motor car, and on some trains baggage, milk or postal cars are regularly hauled. When two trailers are hauled two motor cars are required, making a four-car train. The service has proved immensely popular throughout the Genesee Valley, through which it passes, and it is intended to increase the number of motor cars, in order to handle the business a little more comfortably next season. It is found that the electric trains on their 34 miles of line can be depended on to keep to their running time rather better than the steam passenger and freight trains operating over the main line.



Transverse Section of Plaster Mill.

Signal System.—The railroad company has installed a positive block system for insuring the safety of trains with the frequent headway at which they are obliged to be run upon the single-track road, which must also handle steam passenger and freight traffic at the same time. The blocks extend between the regular way stations, or if such blocks are too long switch towers are added, making the blocks average about 4 miles in length from one end of the line to the other. The sidings are fitted with interlocking switches controlled by the block operators in the towers or in the way stations, and the movement of trains is thus regulated with the greatest care. The towers are all connected by the private telephone line, while the way stations retain the usual telegraphic comunication with the train despatcher's office at Rochester. By means of the telephone communication it is instantly possible for a train crew to get in touch with the chief despatcher and be properly located, but all train orders are transmitted by telegraph and written out on Form 31, as is the uniform steam railroad practice throughout the country.

Telegraph System.—As is well known, the single-phase trolley system causes interference with telegraph lines along the right of way, and unless both the electrostatic and electromagnetic induction are properly compensated there is always danger of telegraphic communication being seriously affected. The static effect is particularly annoying, as it is absolutely continuous as long as the trolley line is charged, whether or not there are any cars moving. Various means were proposed and tried by the Western Union Telegraph Co. for the elimination of the "static," which always causes the telegraphic relays to chatter, but the most successful thus far known is that due to the inventive genius of Mr. E. W. Applegate, quadruplex expert for the Western Union Telegraph Co., who has developed a very simple means for overcoming static interference. Mr. Applegate worked upon the theory that it was useless to try to compensate for the static, and that the thing to do was to pacify the instrument by additional devices.

By this arrangement all the telegraph wires are "singled," and metallic circuits, the necessity for which was at one time pending, were discontinued, and the repeater service which they necessitated was also discontinued, and there is now a spare wire between Rochester and Mt. Morris through the entire zone of static interruption.

Speech over the telephone line is very clear and distinct, and, although the wires and instruments have a heavy static charge, a few simple precautions enable it to be of great use to the operating department. It is intended to carry portable telephones upon the cars.

Miscellaneous.—The single-phase system was recommended for the electrification of this division by the Electric Traction Commission of the Erie R. R., and after authorization by the company was installed under the general direction of Mr. J. M. Graham, vice-president and head of the construction department of the Erie.

The engineering and the construction work were carried out and the system brought into operative condition by Westinghouse, Church, Kerr & Co., who designed and erected the buildings and the catenary trolley construction, bonded the track and installed the electrical apparatus in the sub-station and on the cars.

The adjustment of the telegraph system was carried out jointly by the Western Union Telegraph Co. and the telegraph department of the railroad company.

The order was given to the engineers on June 6, 1906, and, although the intense activity in construction work all over the country at that time rendered it difficult to secure materials and labor promptly, the work was pushed so rapidly that about 7½ months later, on January 22, 1907, the first official trial trip was run between Avon and Rochester. The severe winter weather thereafter prevailing delayed the completion of the work until spring. During April and May the whole equipment of sub-station apparatus, lines and cars was thoroughly tried out in a course of experimental operation, which also enabled the railroad employes to become familiar with the new system. On June 18 commercial operation began and has since continued, with marked success.

The Erie is one of the oldest steam railroads in the country, but that it is also one of the most progressive is demonstrated by its policy of giving a thorough trial to a system of electric traction whose characteristics of simplicity in construction and economy in operation make it so eminently fitted to replace steam motive power wherever the economic conditions point to the desirability of its substitution for the betterment of either passenger or freight service.

Concrete Mixing Outfit for Plaster Mill Mounted on Flat Car.

Steel Reinforcement in Brickwork is advocated by an architect of York, England, who has carried out a number of experiments with brick walls, in which the joints contain galvanized wire netting in the mortar. As a result of the experiments many claims are made for this type of construction, some of which seem a bit far-fetched, such as the assertion that by reinforcing its mortar joints, brickwork can be rendered as monolithic as reinforced concrete. On the other hand, the reinforcement of brick-work, when skillfully done, adds materially to the resistance of the walls to collapse after cracking. Probably a good many readers of The Engineering Record are aware that the brick walls of the famous Palace Hotel, of San Francisco, were reinforced by iron straps on the joints, and one reason that the masonry stood so firmly was unquestionably the presence of this reinforcement.

The New Plaster Mill of the American Gypsum Co.

The new plaster mill of the American Gypsum Co., situated three miles from Port Clinton, O., on the main line of the Lake Shore & Michigan Southern Ry., is 65 ft. wide, 270 ft. long and 35 ft. high from top of foundation walls to the plate of the building. It is constructed in skeleton form entirely of reinforced concrete.

The building was originally designed in steel with corrugated siding for walls, enclosing several very large steel storage bins with runways connecting the bins at various levels, but owing to the poor delivery quotations on the steel, it was decided to construct the entire building and the bins and runways of reinforced concrete. The resulting structure is absolutely fireproof, and the owners do not intend to carry any fire insurance at all, either on the building or equipment.

The price, as usual, was a consideration that had to be dealt with, and as the building originally designed in steel was covered only with corrugated siding, the use of brick or heavy concrete outside walls for the reinforced concrete building was out of the question. The contractors therefore decided to construct it in the skeleton form, using very thin reinforced concrete outside walls.

All foundations for building and machinery were built of concrete composed of one part Portland cement, three parts lake sand and six parts of 2-in. ring broken stone. The foundation walls, except those for basements, are 9 in. thick and are carried up to the ground floor, approximately 5 ft. above grade. This 5 ft. to floor level is filled in with the earth from the excavations and broken gypsum rock from the mine. In the heavy kettle foundation about 70 per cent. of it was composed of this rock laid in courses to within 16 in. of the top of foundation.

The building is divided into panels, 16 ft. across the width of building and from 9 to 24 ft. lengthwise of the building, the varying spacing lengthwise being due to the machinery required for the mill.

The floors at ground level over the basements in most cases support very heavy jaw crushes. The floor slabs are 6 in. thick, reinforced with ½-in. rods on 6-in. centers, and are approximately of 8-ft. span, between beams of 18 to 20-ft. spans. The runways throughout the building were designed to support a load of 80 lb. per square foot, except in special cases where there was machinery to be taken care of.

All of the outside walls above the ground floor are 4 in. thick, designed to resist a wind pressure of 60 lb. per square foot. The first 16 ft. of wall rests directly on top of the 9-in. foundation walls and the upper section of 14 ft. is carried on wall girders, joining all the exterior columns together and forming a belt around the building. The upper belt or plate, 30 ft. above the ground floor, was run at the same time the last section of wall was run, and all the steel reinforcement for the roof beams was placed at the same time, so that it would be securely anchored at the ends. The centering for the walls was made of wood panels 5 ft. high and 8 to 10 ft. long, bolted together with ½-in. bolts threaded at both ends. After the concrete had set 60 hr. the bolts were driven out and used again when raising the panels. Special care had to be exercised in raising the panels so as not to crack the walls, the concrete being green and the walls thin.

At the 16 and 30-ft. levels, cross struts were carried over to the interior columns in very much the same manner as for a steel frame. The struts are 12 in. square at the 16-ft. level and 10 ft. square at the 30-ft. level, with just sufficient reinforcing in each to take care of its own load, with a factor of safety.

The columns supporting these struts also supported the beams. Running lengthwise of the building, the columns, in most cases, were 12 in. square, reinforced with one 1⅛-in. rod in the center. The columns supporting bins were of sections varying from 16 to 24 in. square and reinforced with eight 1-in. rods, fastened together with hoops 12 in. on centers. These hoops were ⅜ in. in diameter, and each hoop was wired to every rod very carefully. The outside wall columns or pilasters were run in sections with the wall and reinforced with one 1-in. rod set 9 in. from the outside of the wall.

The beams are of rectangular section and support shafting, motors, dust bins and runways. The method used for securing the shaft bearings to beams proved to be very efficient; it was accomplished by a timber of the size and length required and fastened either on the top, side or bottom of beams with U-shaped iron clamps and the bearings bolted or screwed on to the timber.

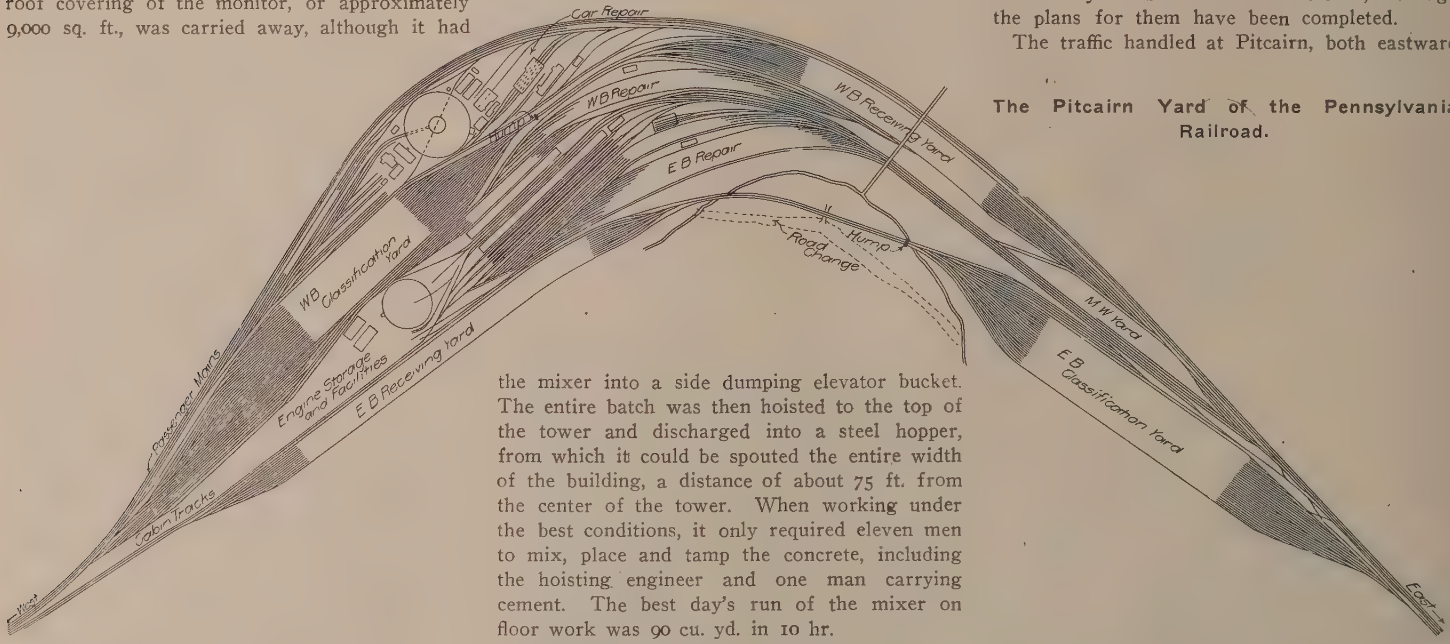
All of the bins except the finish material storage bins have flat floors resting on beam construction supported by columns. The floors of bins are all approximately at the 16-ft. level, reinforced with ⅝-in. rods, on 5-in. centers in both directions for spans between beams 8 ft. 9 in. center to center; the walls of the bins extend to the roof plate in all cases. In several cases the end walls of bins form part of the outside wall of the building. The thickness of bin walls in most cases is 8 in. reinforced with ⅝-in. rods 6 in. on centers vertically, and ¼-in. rods horizontally 12 in. on centers.

The finish material storage bin, 65 ft. wide by 40 ft. long, supported on twelve columns 20 in. square, is designed with arch floor construction, the arches being 16 ft. span, 6 in. thick at the crown, reinforced with ¾-in. rods 12 in. on centers wherever bending occurs. The haunches form beams which are supported every 10 ft. by one of the columns. The outside walls are 18 ft. high, 12 in. thick from bottom to top, and are reinforced with ¾-in. rods vertically on 9-in. centers for the first section of 12 ft., and ½-in.

rods on 9-in. centers for the next section. The outside walls for this bin were run with 3 per cent. of Sandusky waterproof cement added to the concrete while mixing to insure an absolutely waterproof wall.

The roof of the building is the usual type, the first slope being a ⅓ pitch and the roof of the monitor nearly flat. The running of the concrete on the first pitch was somewhat difficult, as it had to be floated smooth and worked up the incline practically by hand. However, after the forms were stripped the under side presented a very even and smooth surface. The roof slabs are 3 in. thick, of 8 ft. span, reinforced with ⅜-in. rods on 7-in. centers with ¼-in. distributing rods on 12-in. centers.

After the roof had been run about 18 days the concrete base was covered with a three-ply composition roof, cemented to the concrete with a roofing cement. After the roof had been down about two months, although not entirely completed, a very severe wind storm wrought havoc with the roof covering. The edges of the covering along the eaves of the building had not been securely fastened, and for this reason all of the roof covering of the monitor, or approximately 9,000 sq. ft., was carried away, although it had all been cemented to the concrete base. This same wind wrecked several other buildings throughout the country, and undoubtedly gave the 4-in. walls and the entire mill a very severe test, as the velocity was about 77 mi. per hour.



The Pitcairn Yard of the Pennsylvania Railroad.

All of the concrete for the building above the ground floor was composed of a 1:2:4 1-in. ring broken stone mixture, using lake sand and Excelsior Portland cement furnished by the Cleveland Builders' Supply Co.

The steel rods used for reinforcing varied in size from ¼ in. to 1¼ in. in diameter, and between 80,000 and 90,000 lb. in ultimate tensile strength. The 4-in. outside walls were reinforced with ¼-in. rods in both directions. The outside wall columns and interior frame columns are reinforced with one 1⅛-in. round rod. Special reinforcing for beams and girders was required, as in most cases they did not have floor slabs to help take care of the compression. All steel reinforcing was very accurately placed and wired before the concrete was run.

The most important factor entering into the construction of the mill was considered to be the vibration, as in buildings of this class it is generally very noticeable. The mill has been in operation since the first of the year and up to date has not developed any signs of weakness or fracture from this cause. There is a very great deal of noise in the building produced by the crushers, grinders, elevators, conveyors, and especially by the tumbling of rock in the steel rotary dryers, 80 ft. long, all of which tends to cause a slight quiver in all parts of the building, that can only be sensed by placing one's ear against one of the members or the wall. This, however, can never cause any damage.

Another remarkable test which has been going on ever since the building was started is caused by the blasting of gypsum rock in the mine directly under the building. The shock of these blasts can sometimes be felt in the neighboring houses about one-half mile from the shaft. The bottom of the shaft is about 50 ft. below the surface.

The concrete mixing and placing was one of the most interesting features of the job, as the equipment, consisting of a mixer, elevating tower and hoist, was placed on a 33-ft. flat car, which traveled alongside of the building. The sand, stone and cement were all placed in the slip bucket at the rear of the tower and hoisted to the mixer platform and dumped. The water for mixing was controlled by a man standing in front of the mixer. The same man dumped the contents of the mixer into a side dumping elevator bucket. The entire batch was then hoisted to the top of the tower and discharged into a steel hopper, from which it could be spouted the entire width of the building, a distance of about 75 ft. from the center of the tower. When working under the best conditions, it only required eleven men to mix, place and tamp the concrete, including the hoisting engineer and one man carrying cement. The best day's run of the mixer on floor work was 90 cu. yd. in 10 hr.

The amount of lumber required was approximately 460,000 ft. B. M. The percentage of waste lumber was very great, because the building was of skeleton construction and lacked typical details. The lumber for surface work was No. 2 pine shelving, bought at $16 per M., and would not stand hard usage.

The entire building was designed and erected under the direction of Mr. W. S. Ferguson, chief engineer of the Carey Construction Co., of Cleveland, O., the contractors for the building. Mr. F. W. Griswold, engineer of the American Gypsum Co., had general supervision of the entire plant.

The Salving of the "Suevic," the 550-ft. White Star liner wrecked off the Lizard last spring, has been successfully accomplished. The uninjured part was first cut away and towed to Southampton. The cutting was done by exploding gelagnite cartridges, ranging from 2 to 10 lb., laid close to the outside of the plates in canvas covers and fired electrically. At Southampton the jagged plates and framing were cut away and preparations made for attaching the new section of the hull. The latter was made at Belfast and, according to "The Engineer," was to be launched and floated to Southampton Oct. 5. There the new 180-ft. part will be joined to the other in a dry dock.

The Pitcairn Yard of the Pennsylvania Railroad.

The Pennsylvania R. R. is at present making extensive improvements in its freight yard at Pitcairn, Pa., 15 miles east of Pittsburg, which were undertaken in order to increase the capacity of the eastbound yard and of the engine and car repair facilities. The westbound yard at the present time has a capacity of about 2,900 cars, and the eastbound receiving and classification yards a capacity of about 1,500 cars, the eastbound advance yard holding about 684. The total capacity of the yard when the new eastbound yard and the new car and engine facilities and transfer tracks are completed will be approximately 7,800 cars, exclusive of running tracks and short connections between the various buildings of the mechanical plant. The total length including the eastbound advance yard is about 15,000 ft. The work on the new yard is now in progress and track is being laid in the classification end, but the new motive power and car repair facilities and the additional transfer storage tracks may not be built for some time, although the plans for them have been completed.

The traffic handled at Pitcairn, both eastward and westward, represents almost the entire freight movement of the Pennsylvania R. R. in the Pittsburg district, which requires distribution and transferring from one branch or division to another. The total movement amounts to 4,000 cars per day, divided about half and half between eastbound and westbound traffic. A considerable part of this originates with or is intended for the large steel and rolling mills and manufacturing plants in the Pittsburg district, and this has necessitated the assignment of classification tracks for the sole use of freight for these industries.

Although the traffic movements in the two directions are about equal in the number of cars and in the proportion of loaded to empties, there is some difference in the classification requirements, though not sufficient to make any radical change in the operation of the two yards. Twenty-seven classifications are required in the eastbound movement and 33 for the westbound, the cuts averaging 2 cars eastward and 1½ cars westward. The tonnage ratings in both directions allow train lengths running from 40 to 50 loaded cars, or 80 empties, and these train lengths naturally have affected the lengths of tracks in the classification and advance yard.

The yard is situated in a valley through which runs Turtle Creek, a muddy stream that rises rapidly in the spring and carries a large volume of water. The creek, forming the boundary of the yard on the north, and the hills, about 300 ft. high, on the south, effectually check the expansion of the yard in these two directions. The creek originally flowed along the base of the hills now occupied by tracks and its bed was thrown 1,500 ft. to the north when the yard was first constructed. The east and westbound passenger mains, the through line between Pittsburg and New York, are carried beside each other along the north of the yard, the westbound main following for some distance the bank of Turtle Creek. Only a few tracks to accommodate the coaches for the Pittsburg suburban traffic, the terminus of which is Pitcairn, are placed north of the passenger mains, and are operated independently of the freight movement in the main yard.

The center of the yard is on a curve or series of curves, the total central angle of which is approximately 68 deg. The east end of the eastbound receiving yard is on a 2-deg. curve, which compounds near the end of the exit ladders into a 4-deg. 45-min. curve. This is followed through the yard by a tangent which ends in the beginning of the classification tracks in 3 to 4 deg. curves, depending somewhat on the direction of the ladders. This yard hugs along the base of the hill on the south, and the passenger mains gradually depart to the north until the maximum width of the yard becomes 1,600 ft. The passenger mains forming the northern boundary of the yard going eastward from the end of the main tangent start on a 2-deg. 45-min. curve when nearly opposite the car repair roundhouse. This compounds near the Pitcairn station into a 1-deg. 50-min. curve and finally into a 30-min. curve alongside of the westbound receiving yard. The tracks of any particular group are as far as possible on tangents and the curvature is thrown into the throats between groups. This, however, was not possible in all cases and consequently the west end of the westbound receiving yard and parts of the car repair and transfer tracks are on curves.

The westbound receiving yard contains one ladder feeding 16 tracks, averaging 62 cars each, and having a total capacity of 968 cars. Exit from it is by means of 2 ladders, 10 tracks on one and 6 on the other. A thoroughfare is maintained around the yard to allow ready access to the transfer or shop tracks without delay in the receiving yard. Two tracks connect with the exit ladders which lead over the hump, where the 2 scales are located, to the gravity classification yard. The latter contains 29 tracks with a capacity of 60 cars each, divided on 4 ladders, and 5 shorter tracks for preferred freight. The total capacity is 1,900 cars.

Alongside the 2 inner ladders are thoroughfare tracks on which the locomotives which bring the car riders back to the hump are operated. Each locomotive is fitted with poling car and the thoroughfare on which it runs, being located alongside the ladders, can be used as a drill track for poling such cars as may stick on the switches. This provision allows of the uninterrupted use of all tracks whose head blocks lie between the hump and a stalled car, since it is not necessary to send an engine in over the ladder, the grade being so designed that a car once freed from the switches is quite certain to have no difficulty in running along the open track. Under the older method of sending an engine in over the ladder, all of the tracks in that particular group are often put out of service until the engine has finished its work and backed out over the hump.

The switches in this yard until a year ago were thrown by hand, but this method has been superseded by an electro-pneumatic system installed by the Union Switch & Signal Co. A switchboard built in 5 banks, with 12 sets of controlling push buttons to a bank, is located at the hump, and at the present time with 42 switches in operation is easily handled by two men. Hand operation of the switches under present traffic requirements would require 11 men, the system therefore effecting a saving of nine men on each shift. Each switch is controlled by two push buttons, above which is a dial indicating the position of the switch, whether opened or closed. The cut slips are handed to the switchboard operators, and no difficulty is found in throwing switches as fast as the cars can be pushed over the hump. The maximum number of cars classified under the new method in 12 hr. is 1,400, while with hand operation 600 cars was the maximum obtained for the same period. Fifteen car riders are employed, and a similar number will probably be required in the new eastbound yard.

The present starting grade on the hump has been found satisfactory, though originally a lighter grade was used. The grade of the first 100 ft. is 3½ per cent., of the next 200 ft., 2½ per cent.; the next 700 ft., extending to the end of the ladders, 1½ per cent.; the following 900 ft., reaching about the middle of the yard, ½ per cent., and the remaining 1,000 ft., extending to the beginning of the exit ladders, 0.2 per cent. The ladders themselves are on a 0.1 per cent. down grade.

The tracks in the classification yards are on 13-ft. centers, excepting where the poles for the arc lights are set, in which case 17 ft. is used. The yard is well lighted by night by lights without reflectors placed along the ladders and the thoroughfare tracks. Access for pedestrians to the portion of the yard lying south of the westbound tracks is had through a twin concrete passage directly under the hump and at the grade of the car repair tracks.

Between the westbound yard and the passenger mains is one part of the car repair plant, consisting of a roundhouse for housing cars which are being overhauled, and the various auxiliary shops for blacksmith, machine, carpenter and paint work. The principal part of the car repairing facilities, however, lies between the east and the westbound yards, and it is in this portion that the proposed improvements in buildings and tracks are to be made. There will be two distinct groups of repair tracks, the westbound having eight tracks with a combined capacity of about 340 cars, and the eastbound 13 tracks with a capacity of 480 cars. These tracks are connected with the receiving and classification yards of the west and eastbound movement by thoroughfare tracks, so that cars can be interchanged without interfering with the other business of the yard. In the repair yards the tracks are alternately on 15 and 24-ft. centers, an extra track of standard gauge with dead ends being placed in the wider space to afford means of conveying repair materials on low push cars to points where needed.

The transfer facilities are very extensive and are demanded by the great volume of freight which requires changing from through to local cars or such other transfer as is usual in a yard of this description. The eastbound transfer storage tracks when completed will have room for about 260 cars and the westbound tracks, eight in number, a capacity of 200 cars. In addition to these there will be four tracks holding about 100 cars, which can be used either for shop or transfer storage. The transfer tracks, in the same manner as those devoted to car repairing, are connected by thoroughfares with both of the receiving and the classification yards, so that access is had to them from the receiving yard, and from them to the end of the classification yards without interfering with the normal handling of freight.

There are at present two 800-ft. transfer sheds in use, each 40 ft. wide and surrounded by platforms. It is proposed to extend one of these sheds 320 ft. and build a platform of the same length adjoining the other. Two open transfer platforms, each 15x1,115 ft., will also be built. For the transfer of heavy freight a 50-ton and two 5-ton cranes, spanning four tracks, will be installed.

A novel arrangement for transferring freight from damaged bottom dump cars is also planned. It will consist of a track elevated 22 ft., beneath which will run a track on the ground level. The damaged cars will be pushed up a 2½ per cent. incline on to this elevated track and dumped into the cars standing on the track below. This elevated track is level for 400 ft. In addition to this arrangement two tracks, each 1,160 ft. long, are provided for transferring from a damaged to a good-order car, such materials as can be shovelled or easily handled and do not need separation to different branch roads.

A considerable increase in engine facilities is planned in connection with the improvements, but the work has not yet been begun. The area now devoted to engine storage tracks and part of the present eastbound yards will be entirely rearranged so as to afford ample room for the motive power department. Seven tracks, each 360 ft. long, located west of the engine roundhouse, will be built first and a large area adjoining these tracks will be left for future extensions. The present roundhouse has 46 stalls, and there are large machine and blacksmith shops for making the repairs usual at a large engine terminal. Seven or eight new buildings are proposed, including a large bunk and store house, 65x180 ft. in plan. The inspection and ash pits are also to be increased in size.

New Eastbound Yard. The eastbound yard is divided into receiving, classification and advance groups. The first two groups of the old yard are now being replaced by the new yard lying to the south at the foot of the hill, and when these are completed the total capacity for eastbound movement will be about 3,300 cars, 915 in the receiving yard, 1,700 in the classification and 680 in the advance yard. The receiving yard lies opposite the westbound classification yard and is separated from it by the engine and car repair tracks. The classification yard is east of the westbound receiving yard, the entrances of the two being about opposite each other, and the advance yard, being still farther east, is entirely out of the main-yard area. The throat between the receiving and the classification track has been made very long, about 1,400 ft., this being necessary to throw the classification yard as far as possible beyond the hill which curves here to the north and ends in a neck through which a wide cut has been made to accommodate the yard entrance.

The receiving yard has 13 tracks, each about 3,050 ft. long, with a capacity of 76 cars each. Six of them are on one ladder and seven on the other, while the last track is devoted to running purposes. The classification yard has 26 storage tracks with an average capacity of 66 cars each, arranged on five ladders. Four thoroughfare tracks have been provided, two of them placed between adjacent pairs of ladders, one alongside the remaining ladder, and the last on the extreme south side of the yard. These thoroughfares will be used, as described for the westbound yard, for operating engines hauling poling cars, which will perform the double duty of freeing such cars as stick on the switches and returning the car riders to the hump.

The receiving yard is on an ascending grade of 0.7 per cent., which at the beginning of the exit ladders changes to 1.4 per cent., and continues at that rate through the throat until within 200 ft. of the hump. The starting grade on the hump for the first 100 ft. is 3½ per cent.; for the next 200 ft., 2½; for the next 800 ft., 1½;

for the next 2,300 ft., 0.4 per cent. From this point there is an ascending grade of 1 per cent. for 800 ft., where the tracks connecting the classification and advance yards attain the same elevation as the main-line tracks. This arrangement of grades puts all of the ladders on a 1½ per cent. grade, and this fact combined with the use of poling cars on the drill track alongside the ladders will insure against cars sticking and giving trouble on the switches. The centers to be used are the same as in the present westbound yard, 13 ft., except between those tracks where the poles for the electric light wires are placed, the centers here being 17 ft. The lighting of the yard has been given special consideration, and as a result of the experience gathered in the westbound classification yard the arc lights have been placed not only along the ladders, but throughout the entire yard.

The advance yard contains six tracks with a total capacity of 680 cars, each track being long enough to hold two loaded trains.

The drainage of the yard has proven quite a troublesome question, and has necessitated four distinct drainage channels through the yard. As stated before, Turtle Creek originally skirted the hills which now form the southern boundary of the yard, and the changing of its course to its present location makes it necessary to convey by artificial means the water draining from the hills and through a number of small draws. At the west end of the yard a drainage ditch 10 ft. wide and about 6 ft. deep has been constructed to carry a stream from one of the draws and discharge it into an 8-ft. arch culvert leading under the tracks to Turtle Creek. The ground which will be occupied by the new engine facilities is too low to drain by gravity, and for that reason a pumping system will be installed. Suitable catch-basins and drains will be provided to convey the water from the low area to a sump, 25 ft. in diameter and 25 ft. deep, built of concrete. Part of this sump will be partitioned off into a chamber in which two pumps, one electrically and the other steam driven, will be installed. The pumps will be started automatically by means of floats, the electrically driven pump being relied upon for the major part of the work and the steam-driven held in reserve as an auxiliary. From the sump the water will be forced through a 24-in. cast-iron pipe to Turtle Creek. The pipe was laid under the network of tracks by opening up a ditch of the length of two sections of pipe and completing it before carrying the work farther. The ground through which the pipe runs was of such a nature that it was not deemed safe to lay the pipe without a foundation, and for that reason it has been constructed on a layer of concrete 34 in. wide and 5 in. in depth. After it was in place and caulked it was completely surrounded with a concrete covering just sufficient in thickness to cover it well on all sides. Another drain pipe, 36 in. in diameter, runs through the area which is to be drained by the pumping system just referred to, but is on such a grade and at such a depth that it can carry only the water collected at the foot of the hill.

Continuing eastward through the yard, another drainage system is encountered, near the hump of the new eastbound classification yard. It consists of two 36-in. cast-iron pipes laid side by side and draining three small draws. The water is delivered to these pipes from the points where it is collected by an open concrete drain 2½ ft. deep and 4½ ft. wide. About 600 ft. from the end of the classification yard a double 3x4-ft. box culvert has been built to care for the drainage of that portion of the yard. A ditch 2,500 ft. long collects the water and carries it to the south end of this twin box. Between the eastbound classification and advance yards Brush Creek crosses the right-of-way through a six-track, three-span masonry bridge. The spans are each 25 ft., with a 9-ft. rise, the springing line being 8 ft. above the bed of the creek.

Ample provision for fire protection has been made by water mains throughout the entire yard, hydrants being placed at convenient intervals.

The Construction of the New Yard.—The work on the new eastbound receiving and classification yards was started in April, 1906, and at the present time the tracks are laid in the receiving end, but the grading is still in progress for the classification tracks. The greater part of the receiving yard is constructed on a fill from 8 to 25 ft. high, rising toward the east end of the yard in order to attain the proper elevation for the hump. The material for this fill is secured from the heavy cut at the entrance to the classification yard. The latter lies partly in the cut referred to and partly upon filled ground, the cut in one place running to the maximum of 70 ft., and the fill from 5 to 30 ft. The total excavation is 1,175,000 cu. yd., of which 804,282 yd. are in the large cut above referred to.

The Nelson Street Viaduct, Atlanta, Ga.

The material encountered is principally shale, which disintegrates upon exposure to the weather, but which had to be blasted for rapid removal. A light layer of mixed soil, sand and gravel overlies the shale, which is about 25 ft. thick, and beneath the latter is a bed of low-grade lime-stone. The holes used for the blasting were drilled by three Star portable drilling machines, and in all cases went down to the grade it was desired to secure at the point where they were sunk. The holes averaged between 35 and 40 ft. in depth, the maximum being about 70 ft. The diameter of the holes was 6 in. Where solid rock was encountered eight Ingersoll-Rand steam-driven drills were used. Large masses of stone and shale which could not be economically broken up by hand were mud capped. Soil was removed by Bucyrus 70-ton steam shovels, two working on each side of the hill through which the throat of the yard has been cut. After the major part of the work was completed, but two of the shovels were required to complete the work, and these are still in operation. The earth and rock were removed by 3-yd. side dump cars running on 42-in. tracks, and wherever possible these cars were operated in good sized trains so as to avoid delaying the shovel. In order to do this it was necessary in one case to cut a bench of considerable length on the side of one of the hills in order to back a long train of dump cars on to it and thus save time over the other method of merely backing a few cars at a time alongside the shovel. The first cut of the shovel was taken in the hillside at the sub-grade level and the soil merely thrown to the opposite side, thus forming a bench upon which the narrow-gauge track was laid. The work was continued in the customary fashion, the narrow-gauge track being moved laterally as fast as the fill outside of it was completed. The work has required the use of 17 narrow-gauge locomotives and 180 side-dump cars. The contractor for the work is H. S. Kerbaugh, Inc., Philadelphia.

In connection with this work it has been necessary to make a road change about 2,000 ft. long and to construct an arch beneath the throat between the receiving and the classification yards in order to connect the highway with an overhead bridge spanning the old yard. The arch is of masonry 46 ft. long, with a span of 30 ft. and a rise of 7½ ft. A track running off to the right at the east end of the eastbound classification yard has necessitated a change of the channel of Brush Creek, and this was done by means of a steam shovel working in the new bed of the stream. Another piece of work done at the same time, but independent of the new yard construction, was a retaining wall of concrete at a change in the course of Brush Creek alongside the advance yard. The wall is 5 ft. high, 3½ ft. thick and 1,400 ft. long. It is composed of 1:2:5 concrete with dredged sand, and gravel up to 1½ in. in diameter. The material was mixed in a Smith mixer mounted alongside a track on the north side of the creek; although the retaining wall itself is on the south bank. This arrangement requires all of the concrete to be wheeled across the creek, and for this reason light timber runways were thrown across from bank to bank at three different points, and the mixer moved opposite these as the work progressed. The advantage of keeping the mixer on the north bank was that only one class of material, the mixed concrete, was wheeled across the water, whereas if the mixer had been placed on the south bank the sand, gravel and cement would all have had to be taken over the creek separately.

The construction of the new yard is in charge of Mr. N. F. Brown, assistant engineer, Pennsylvania R. R., Pittsburg, Pa.

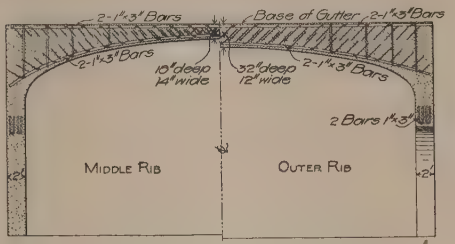
The Nelson Street Viaduct at Atlanta.

The old steel viaduct, which formerly carried Nelson Street, Atlanta, Ga., over the yards of the Southern Railway, recently has been replaced by a reinforced concrete structure 479 ft. 3¼ in. long, made up of ten flat arch spans, seven of which are between 40 and 50 ft. in clear span, the remaining three having spans of 75 ft., 53½ ft., and 20 ft. 5⅝ in., respectively. The width of the new viaduct from center to center of outside arch ribs is about 32 ft. This is the width of the roadway proper on which is carried vehicular traffic and in the center a double-track street car line. Outside the roadway on each side is a 9-ft. sidewalk carried by reinforced concrete cantilever beams, as shown in accompanying illustrations. The clear headroom over the main and freight yard tracks is 21 and 18 ft., respectively. From one end the roadway rises on a 2 per cent. grade for 100 ft.; then it meets a vertical curve 40 ft. long; and the remaining 339¼ ft. is on a 2 per cent. downgrade to the other end. In the yard the viaduct crosses over two canopied freight platforms, inbound and outbound respectively, one of which may be seen in an accompanying illustration.

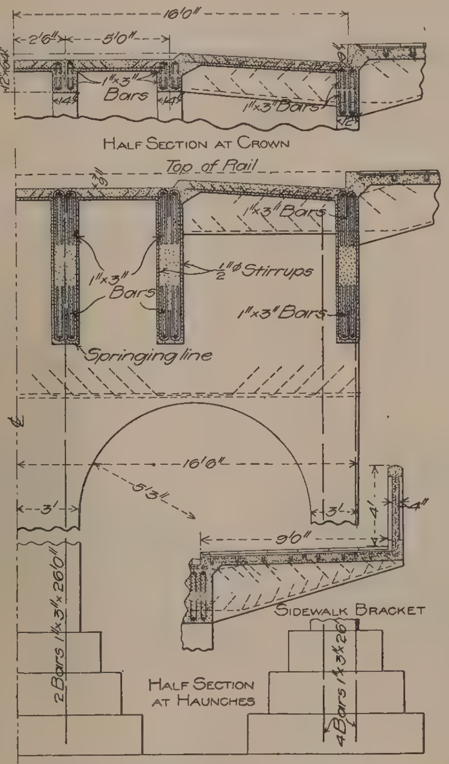
The arches are of the ribbed type, reinforced with Kahn trussed bars and built continuously through the supporting piers. There are six ribs supporting each span, four in the center spaced 5 ft. on centers under the street car tracks and the two outside under the curb lines of the driveway. The cantilever beams supporting the sidewalks are 10 ft. on centers and are attached to the two outer ribs on each side. The ribs are designed to support: The dead load imposed by the concrete and road materials, assumed as 140 lb. and 100 lb. per cubic foot, respectively; 100 lb. per square foot live load on the sidewalk; 100 lb. per square foot or a 15-ton moving road roller on the driveway; and a succession of 40-ton electric cars on the track ribs.

Five successive spans over the freight yards, ranging from 40 ft. ⅛ in. to 44 ft. 2¾ in. in length are typical. In these spans each of the four ribs under the car track is 14 in. wide and 18 in. deep at the crown, while those under the curb lines are 12 in. wide and 32 in. deep at the same point. The depth in each case includes the 6-in. floor slab which was built continuously over the ribs in the same manner that the latter were built through the piers. Each rib in these spans is reinforced in both intrados and extrados with two 1x3-in. Kahn bars arranged in general as indicated on an accompanying diagram. Toward the ends of each rib, where the shear prongs of the bars in the intrados and extrados do not meet, ½-in. stirrups are used as shown. The top rib bars are continuous through the piers, the ends of successive rods lapping at the centers of the spans. In general this system of reinforcement is characteristic of the other spans, though it differs in detail owing to variation in span and size of arch ribs.

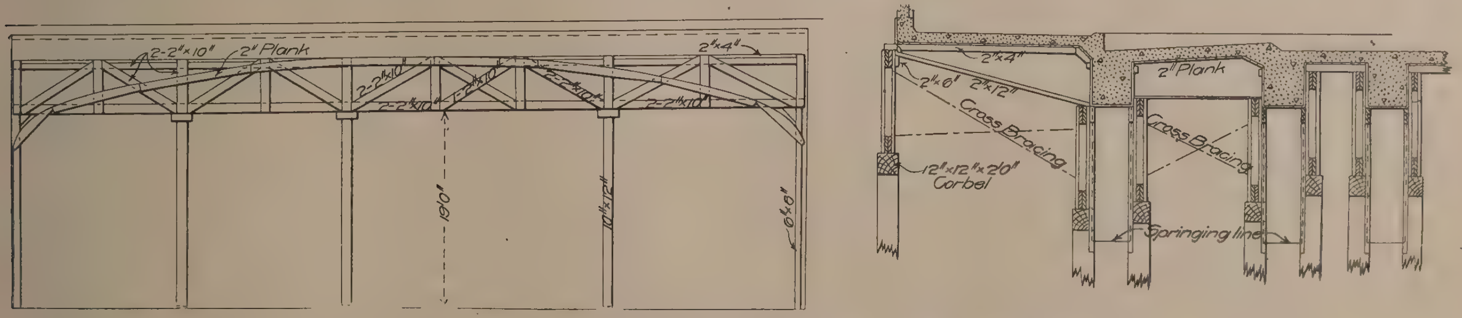
The 6-in. floor slab is reinforced over the track ribs with ½-in. transverse bars 18 in. on centers. Between the outside rails and the curb line the reinforcement is ½-in. transverse rods 15 in. on centers. The 5-in. sidewalk slabs have ½-in. longitudinal rods 15 in. on centers. Over the four center ribs the floor slab is depressed about 4 in. to afford room for the street car rails, the tops of which are flush with the 4-in. wood block pavement. The reinforcement of the cantilever sidewalk brackets and the concrete railing is indicated on the drawing. Where the beam opposite the bracket is omitted, as it has been where the position of the piers prevented its construction, the upper rods of the bracket are extended into the floor slab and the lower rods are tied into the outside arch rib.



Sections of Ribs of Typical Span.



Cross Sections of Typical Span.



Elevation and Section of Centering for 75-Foot Span, Nelson Street Viaduct.

The piers in the freight yard, where the clearance is 18 ft., are 2 ft. thick, while those supporting the higher spans over the main track are 3 ft. thick. Each pier is pierced with two arched openings 10½ ft. wide, three legs being thus formed. Of these, those on the outside are 3 ft. wide each, while the middle one has a width of 6 ft. Each leg rests on separate stepped footings carried down to a maximum depth of 6⅔ ft. below the top of the rails. The reinforcement in the piers of the typical spans consist of two 1x3-in. bars placed just above the soffit plane of the arch openings and four 1x3-in. bars in each pier leg extending from the bottom of the footings up to the floor slab.

The construction of centering for most of the spans presented no problems of unusual difficulty. Two spans, however, 47 and 75 ft. long, over the main line tracks had to be constructed without interrupting or endangering traffic on any of these tracks. This prevented the placing of the usual intermediate falsework between the piers and necessitated carrying the centering on wooden Howe trusses arranged as shown by accompanying sketches. The concrete was prepared in a No. 1 Smith mixer, a 1:2:4 mixture being used for the arch ribs and floor and a 1:3:5 mixture for the piers and footings. The stone was crushed in an Aurora crusher, driven by a 15-h.p. Frick engine, and was hoisted into bins from which it was drawn out as needed on a platform at the mouth of the mixer. The latter delivered to skip cars which were hoisted up an inclined track to the deck of the bridge by a Lambert single-drum hoist taking steam from the crusher engine boiler. On the bridge the skip cars were switched on to the proper track by a turntable. The entire contract involved the placing of about 2,500 cu. yd. of concrete and 100 tons of reinforcing steel. Work was begun May 1, 1906, and was completed January 1, 1907.

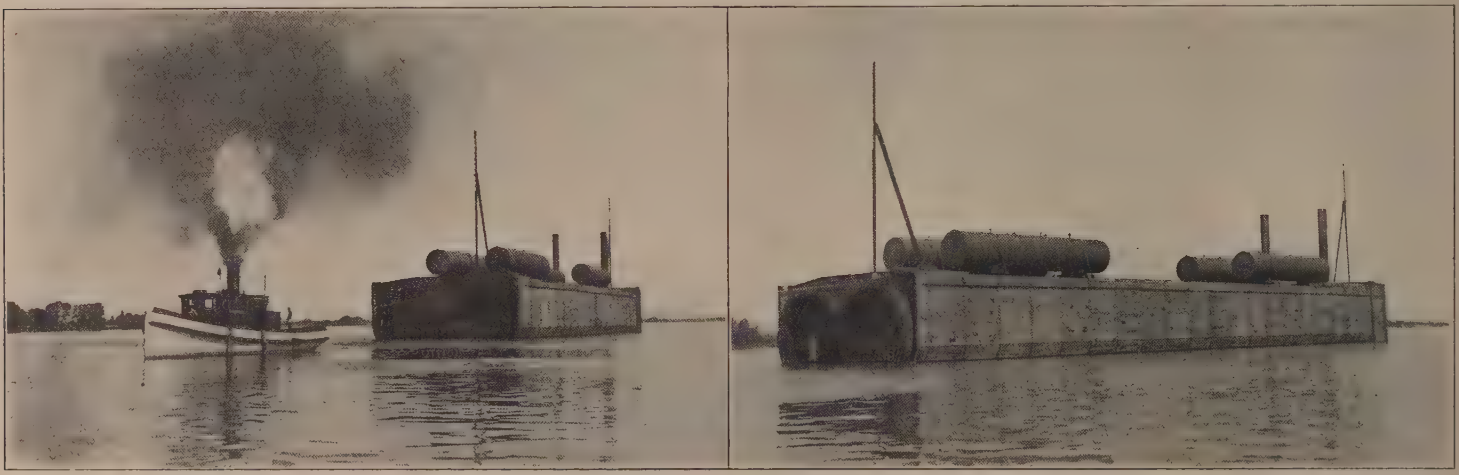
The viaduct was designed by the Trussed Concrete Steel Company, subject to the approval of Mr. D. W. Lum, chief engineer of maintenance of way, Southern Railway. Mr. W. W. Griffin, of Atlanta, was the contractor.

Perforating a Well Casing in Position.

Drilling apparatus has been used by Messrs. Merryweather & Sons, Greenwich, England, in sinking an artesian well. The well, which was lined with 12-in. pipe, had been driven through a water-bearing stratum in the hope of securing a more abundant flow at a lower level. This hope was not fulfilled, and it was decided to tap the stratum that was first penetrated. The well casing had cut off this flow, and it was necessary to perforate the pipe by drilling from the inside. Two drills, to each of which was keyed a bevel gear-wheel, were mounted horizontally, pointing in diametrically opposite directions, and a third bevel gear-wheel, keyed to the vertical boring rod, meshed with these two. To feed the drills the inner ends of the drill shafts were threaded, and each carried a miter wheel tapped to fit the drill shaft. Another wheel on the vertical shaft engaged these wheels, and, the gear ratio of this set of wheels being different from that of the driving gears, as the boring rod turned the drills revolved more rapidly than the threaded spindle wheels, and so were fed forward.

The Detroit River Tunnel Caissons.

The general design of the Detroit River tunnel was illustrated in The Engineering Record of Feb. 17, 1906, and details of the method of construction finally adopted were explained in the issue of March 2, 1907. There are to be two tubes, 20 ft. in interior diameter and 26 ft. 4 in. apart on centers, leaving a clearance of 3 ft. between them on the center line. Each tube has a riveted steel shell 23 ft. 4 in. in diameter, the pair of them for each section being placed in a long pontoon, which also serves as a mold or form to retain the concrete, which will be filled in around the steel shells after the section has been sunk into place in the trench dredged for it. The upper part of the trench is excavated by a dipper dredge, and the lower part by a clam-shell dredge provided with a specially designed bucket. The subaqueous portion of the tunnel will consist of ten sections like that illustrated, each about 260 ft. long. The shells on top of the section are air chambers, which are used in sinking the tubes, an operation which it is planned to carry out as follows: Inlet valves in the bottoms and outlet valves in the upper part of the bulkheads are opened, so that water enters through the former and air escapes through the latter, causing the tubes to sink slowly until the outlet valves are submerged. The latter are located so as to retain a certain quantity of air above them, which gradually escapes through vent valves, operated from the attendant scows. Finally enough additional water is admitted to sink the tubes below the surface, until the air cylinders on top commence to be submerged and maintain the tubes in a horizontal position, preventing them from sinking farther until their buoyancy is overcome. The air cylinders are ballasted by admitting water ballast or expelling it with compressed air, until the combined weight of the tubes and the cylinders produces a tension of only about 10,000 lb. on the lines attached to each end of the section. It is thus maintained in even balance and gradually lowered to the bottom under perfect control, without danger of severe stresses or distortion. The tunnel is being built, under the supervision of Mr. W. S. Kinnear, chief engineer of the Detroit River Tunnel Co., by Butler Bros.-Hoff Co., of New York City. The general plan followed is a modification by the contractors of a plan suggested by Messrs. W. J. Wilgus, H. A. Carson and W. S. Kinnear, the committee which originally studied the project for the New York Central interests. The committee outlined four different methods of construction which would be acceptable, and permitted the contractors to suggest modifications, or entirely different plans.



Tunnel Caisson for Twin Tunnels under the Detroit River.

A By-Product Charcoal-Iron Plant at Marquette, Mich.

The Marquette, Mich., charcoal-iron plant of the furnace department of the Cleveland-Cliffs Iron Co. is fully equipped to reclaim a large percentage of the by-products from the smoke produced in the manufacture of the charcoal used in the plant. The latter has an average daily output of 125 tons of first grade charcoal pig-iron, which is produced by a single blast furnace. A group of eighty-six bee-hive brick charcoal kilns, a number of buildings in which by-products are made from the smoke and a large central power station supplying steam and power are also included in the plant. The iron-ore used in the manufacture of the charcoal iron is delivered from the mines of the company at Ishpeming and Negaunee over the Lake Superior & Ishpeming Ry. The latter was built, and is operated for handling iron-ore from mines in the Marquette district to docks on Lake Superior at Marquette. The construction, equipment and operation of this road were briefly described in The Engineering Record of Aug. 31, 1907. Switching connections are extended into the plant from the Marquette & Southeastern Ry., an allied line which extends along the site of the plant. The large quantities of wood required in making the charcoal used in the manufacture of the iron are also delivered by rail from extensive forests reached by the Marquette & Southeastern Ry., and by the Munising Ry., a second allied line.

An outline general plan of the plant, showing the relative location of the principal parts of the latter, is given in an accompanying illustration. The iron-ore is delivered to a large stock house containing a number of elevated storage pockets. In front of this house are the blast furnace and a casting house, the central power station and the auxiliary buildings of the plant. In the rear of the stock house are the charcoal kilns, and back of them, the group of buildings in which the by-products are made from the smoke produced from these kilns during the manufacture of charcoal.

The ore stock house, 100x300 ft. in plant and 44 ft. to the eaves line, has sheet-iron sides and a corrugated sheet-iron roof, carried by steel roof trusses. Two switch tracks are extended longitudinally through it on trestles, at a height of 25 ft. above the floor. One of these tracks is over a row of fourteen ore storage pockets, with a capacity of 100 tons each, which are along one side of the building. The other is approximately on the center line of the building and is intended to deliver ore to piles on the floor of the building in case the mechanical equipment installed for handling ore from the storage pockets to the blast furnace is out of commission.

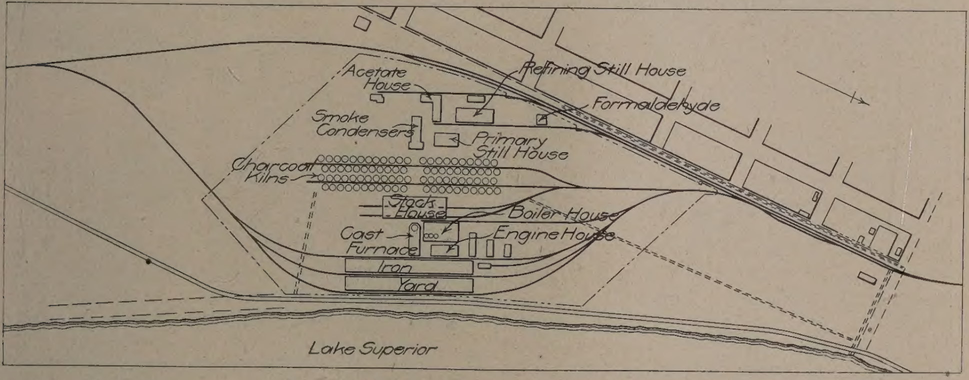
The ore is handled from the storage pockets to the base of a steep incline leading to the top of the blast furnace, in electrically-operated scale hopper cars. A 36-in. gauge track extends the length of the row of storage pockets in a pit depressed slightly below the floor of the building. A system of tracks also extends to the charcoal kilns. Each of the cars operated on this system of tracks has its hopper-shape body arranged so it can be swung on a weighing-scale frame carried by the car truck. These cars are equipped with street railway motors and controllers. Power is taken from a double trolley supplied with current from the central station. The cars each have half the capacity of one of two skips in which the materials are hoisted up the incline leading to the top of the blast furnace. The charcoal and the lime used for flux are delivered to these charging skips in two-wheel iron carts on transfer cars handled by electric locomotives.

The blast furnace is at one end of the cast house, the latter being 50x155 ft. in plan. The furnace is very similar in arrangement to the modern blast furnaces in which iron-ore is reduced to pig with coke, and it is operated in practically the same manner as are those furnaces. It is 12 ft. in diameter and 70 ft. high. A large blowing engine in the central power station supplies heated air blast to it at a pressure of 8 to 12 lb. per square inch. The gases driven from the top of the furnace are utilized in firing part of the boilers in the central station, and also three 17x70-ft. Cowper Roberts brick-lined stoves through which the air blast is passed before reaching the furnace. The charcoal and iron-ore are placed in alternate layers when the furnace is charged, but, as in the coke-fired process, a fire is always maintained. Four heats are drawn from the furnace every 24 hr., two heats during the day and two during the night.

This blast furnace has made a phenomenal record for charcoal practice, since it has been in contінous operation for over four and a half years. This record, however, is eclipsed by the Gladstone furnace of the same company, which has been in continuous operation for over six years and seven months. These records are the more remarkable when it is considered that the average blast of charcoal furnaces in Northern Michigan averages something less than two years. These long blasts are due to the fact that the furnaces are equipped with the Farrell bosh jacket, used in connection with the Gayley bronze bosh plates. The Farrell jacket absolutely prevents the tipping or sagging of the bosh plates and the moving of the bosh brick through expansion or contraction.

The floor of the cast house is a deep bed of lake sand into which the iron is drawn from the furnace. One central ditch, or furrow, extending the length of the building from the tapping hole of the furnace, is thrown up in this sand. Latteral transverse furrows are taken from this main furrow at intervals of about 6 ft., and a row of smaller, secondary longitudinal furrows, each 54 in. long are taken from each latteral, thus forming a complete gridiron of furrows.

The transverse lateral furrows are at succeedingly lower levels, receding from the furnace, so those closest to the latter are filled first when the cast is made. The molten-ore is drawn freely from the furnace into the furrows until slag appears in it, when a skimming gate is placed in the central furrow near the furnace. As the proportion of slag increases this gate is gradually lowered, the iron being heavier passes under it, while the slag is diverted to one side into a ditch leading to an open area at the side of the building. Meanwhile, as each lateral and the secondary longitudinal 54-in. laterals leading from it are filled, a loose paddle-shape iron gate, coated with fire clay, is thrown into the connection with the main furrow to cut off the supply from the latter. The iron in the 54-in. laterals is broken from the main laterals while hot with hand sledges. The whole mass is then cooled by sprays of water applied from overhead perforated pipes along the side of the building. When sufficiently cooled, the iron is removed and preparations are made for another cast.



General Plan of Charcoal Iron Plant.

The central power station comprises a 90x168-ft. boiler house and a 50x130-ft. engine house. The boiler house contains twelve five-drum Stirling water-tube boilers, each with 3,412 sq. ft. of heating surface. Eight of these boilers are in a row along one side of the boiler house, and operate at 140 lb. pressure; the remainder are in a second row along the other side and also operate at 140 lb. pressure. The boilers in the row of eight are each equipped with a Murphy stoker for coal firing, but are fired chiefly with gas from the blast furnace and with liquid tar and oils furnished from the by-product portion of the plant. Such coal as is used is delivered at the boiler house in cars, from which it is dumped into a track hopper. The coal passes from the latter through a coal crusher and thence into a Link-Belt overlapping-bucket conveyor that elevates it to a row of storage bunkers over the row of eight boilers. The tar and oils used under the boilers are quite fluid, and are supplied through nozzles under a pressure of 100 lb. They are delivered to the boiler house through brass pipe lines, as they attack all metals, except copper. The blast furnace gases and the tar and oils can be fired separately or together, as desired. The boilers in the row of four are fired with furnace gases, tar and oils and coal breeze.

The boilers are all operated on induced draft and are served by a Green economizer with 13,340 sq. ft. of heating surface. The induced draft is supplied by either of two 5.5x14-ft. fans, each driven by a separate 12x16-in. direct-connected simple condensing engine. A 12x40-ft. steel stack serves all twelve boilers.

The feed water for the boilers is supplied from a hot well by either of two Prescott compound condensing 9x18x12x9½-in. pumps in the engine house. All other units in the engine house are also operated condensing, the condensed water being delivered to the hot well. Condensation from the chemical plant is also returned to this well. The feed-water connections to the boilers are made at the front end of the latter, but all feed-water supply lines are in duplicate, and duplicate connections are provided at the boilers.

A 22-in. steam-supply main under a pressure of 140 lb. is extended overhead from the boiler house to the buildings in which the by-product processes are carried on, large quantities of live steam being required in these processes. A 12-in. steam-supply main, also under a pressure of 140 lb., extends from the boiler to the engine house; and an 8-in. auxiliary steam line is extended to this house for emergency use. All of the boilers in the boiler house are connected so steam can be supplied from any of them to any of the mains.

The blowing engine in the engine house which furnishes air blast for the furnace is a Southwark cross-compound condensing unit, with 22x36-in. and 46x36-in. steam cylinders, and two 48x48-in. air cylinders. The two sides of the unit are disconnected so either side can be operated separately in case the other is out of service. This arrangement assures a continuous supply of air to the furnace with the one unit. The latter is served by a Weiss counter-current condenser, with a capacity of 24,000 lb. of water per hour. This condenser also serves the other steam-consuming units in the engine house. Circulating water for it is obtained from the general distribution system of the plant.

Electric current for operating the industrial railway system, for lighting and for driving motors in various parts of the plant, is supplied by two 150-kw. 220-volt direct-current Westinghouse generators, each direct-connected to a 16 and 27x16-in. compound-condensing automatic vertical Westinghouse engine. Either of these two units is capable of carrying the load on the station, so they are operated singly at alternate intervals.

The engine house also contains three horizontal 11½, 18 and 30x24x20¾-in. triple-expansion condensing Prescott pumping engines, each with a capacity of 5,000,000 gal. These pumps supply water from an intake in Lake Superior to the general system of the plant, at a normal pressure of 60 lb. per square inch, but can operate against a pressure of 180 lb. for fire service. Any two of them are capable of furnishing the water required, the third being held in reserve.

The eighty-six kilns in which the charcoal is made are arranged in four parallel rows, twenty-one in each of two rows, and twenty-two in the other two. These kilns are 30 ft. in diameter and are arranged much the same as an ordinary brick kiln. Various kinds of wood, including hard maple, elm, beech and tamarack, are used in making the charcoal. This wood is all obtained about 60 miles east of Marquette, where extensive forests are to be found. As practically all of the wood in a tree can be utilized, very little waste is occasioned. The wood is delivered to the plant on standard-gauge flat cars, 260 cords, or about 17 cars, being furnished to the charcoal kilns each day. A switch track is laid between each two side rows of the kilns, and the latter have doors on the side next to the track, so the wood can be placed directly in them from the cars.

The wood is placed in the kilns in regular rows and layers, in order to utilize the capacity of the kiln as fully as possible. On the average, however, about 5 per cent. of the space in the kiln cannot be filled. After the kiln is charged, the wood is fired and the charging door is closed tightly with brick masonry, to prevent oxidation of the carbon in the wood. The kiln is then allowed to burn out, which requires from six to eight days, the wood shrinking about 20 per cent., on the average, during that time. When a kiln has been burned, it is allowed to cool, after which the charcoal is handled directly to the charging hoppers of the blast furnace in the two-wheel iron carts on the electrically-operated transfer cars.

Every kiln in the group has a smoke flue connected to a main flue leading to the by-product portion of the plant. These flues are each arranged with a damper, so any kiln can be completely isolated. The draft in the flues is induced by seven 70-in. copper fans, each driven by a 15-h.-p. motor. The smoke being conveyed by the main flue to a series of fifty-six cooling towers in which it is reduced to a liquid. These towers are large wooden, vertical surface condensers supplied with water from the distribution system of the plant. The liquified smoke is delivered to settling tanks in which the tar and oils, which make up about 3 per cent. of it, settle to the bottom, being heavier than the remainder. When the contents of a tank are completely settled the lighter liquids at the top are drawn off and delivered to the by-product buildings by a centrifugal pump driven by a water wheel operating on the water discharged from the condensers. The tar and oils are then pumped to the boiler house by a motor-driven centrifugal pump, as no attempt has been made as yet to refine them.

The lighter liquids are pumped to a 60x112-ft. building containing a number of large stills in which a secondary separation is made. The distillate from these stills is delivered to a 66x182-ft. refining still house, while the residue is utilized in producing lime acetate. The lime is added to the liquid in large mechanically-stirred mixing tanks in the primary still house, after the first distillation is made. The residue from the second distillation is conveyed to a 38x96-ft. building containing a long steel-plate drying floor, heated from beneath, on which the moisture is driven from the acetate. Rotary kilns, similar to cement kilns, have been tried for this process, without success. Equipment is also being installed to make lime acetone as a by-product of the lime acetate process.

The liquids delivered from the primary still house to the refining still house are passed through a series of stills in the latter, the final product of which is wood alcohol. This is produced in various grades up to 99½ per cent. pure. A further refinement is made in a separate 48x96-ft. building in which pure formaldehyde is made.

Mr. Wm. G. Mather is president and treasurer of the Cleveland Cliffs Iron Co. Mr. Austin Farrell is manager, and Mr. Geo. J. Slining is chief engineer of the furnace department.

The Panama Canal Relief Map at the Jamestown Exposition.

By Charles H. Johnson.

Early in January, 1907, the authorities at Washington decided to construct at the Jamestown Exposition a large relief map which should show the Panama Canal as finally planned, together with the topography of the surrounding country. After some correspondence the writer was selected to undertake the actual construction, finally receiving orders early in March to proceed to the Exposition via Washington. The office end of the work was in charge of Mr. Ralph Whitman, then on the staff of the Isthmian Canal Commission, who had collated all available information in regard to the topography and placed it on a large map of the route of the Canal, scale 1 = 50,000, taken from the report of the Commission of 1905, and mounted on cloth.

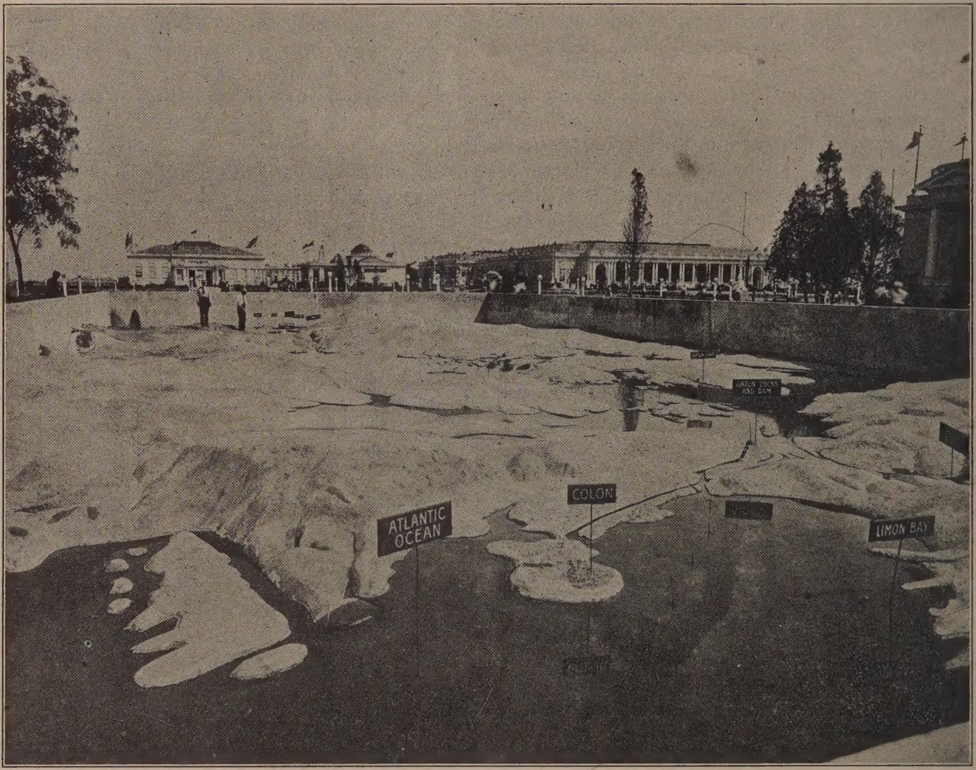
On arriving at the site of the work on March 11, the space allotted to the model was found to be covered with contractors' shanties, one being in the process of demolition. The labor situation was bad, wages for common labor being $1.75 for eight hours, and the labor very scarce and inefficient. Cement finishers were almost impossible to obtain and wanted 50 cents an hour. Stone and cement for the concrete were bought from one of the large contracting firms doing work at the grounds, and were taken from cars on a track alongside the work; sand was obtained from the beach, about 200 ft. away.

After looking the situation over the map was laid out, the dimensions being 122 ft. east and west and 50 ft. north and south, its axes corresponding with the center lines of two of the government exhibit buildings, its horizontal scale being 1 = 2,000. The ground at the site was level; excavation showed, first, 1 ft. of top soil mixed with roots, then about 3 ft. of sandy clay, then 18 in. of sand, then clay at ground-water level. It was decided to make sea-level on the map about 2 ft. below the natural surface of the ground, so that by grading up the spoil to form a raised walk around the map visitors would be sufficiently above it to see over the tops of the hills.

Some Greeks were put to work stripping off top soil and excavating for the Atlantic Ocean. A search for cement finishers produced a couple of negro helpers or second hands, who were willing to work for $2.50 a day and stayed with the work to the end. The Greeks proved unsatisfactory and were discharged after about a week, their places being filled by negroes, who were, on the whole, very satisfactory labor. One white man, at $60 per month, was hired to run rod, hold tape, assist on carpenter work, etc., and, with the writer and the negroes, varying from 6 to 12 in number, constituted the entire working force.

As soon as a sufficient area had been stripped work was started on laying out the Atlantic Coast line. The first method used was by setting up a plane table at one of the corners of the relief map, setting the edge of the alidade rule through the corresponding corner of the paper map and the point to be staked out, then scaling the distance and setting the corresponding point on the ground. This method proved to be too slow and was discarded in favor of one, developed by the writer, which was as follows: The paper map was ruled off in rectangles corresponding to 20x30 ft. on the ground, then a piece of tracing cloth the size of one of these rectangles was ruled off in squares corresponding to 1 ft. square on the ground. The tracing cloth was laid on one of the rectangles on the paper map, the corners of the corresponding rectangle on the ground were staked out, and poles, marked off in feet, were laid 1 ft. apart, parallel to one side of the rectangle. Then noting where the coast line crossed the lines of the tracing, a line was drawn on the ground through the corresponding points of the poles. When the coast line had been thus marked out the clay was carefully cut away with a mattock and the bottom of the ocean leveled off 6 in. below sea level, thus allowing 3 in. for concrete and 3 in. for water.

As soon as two or three hundred square feet of subgrade was ready the concrete was laid, the base being 2½ in. thick, one part cement, three parts sand and six parts gravel or broken stone, mixed fairly wet. The top was ½ in. thick, mixed one part cement and two parts sand, and was troweled to a smooth finish when it was to be covered with water. After the bottom of the Atlantic had all been laid work was started on the land, the hill tops and rivers being located by the same method as the coast line. Stakes were set to the proper grade for the hill tops, the river valleys were chopped out of the clay, being tested frequently for grade with the transit as the work proceeded, then the country between the hill tops and the rivers was modeled in to correspond with the contours on the paper map, and concreting begun.



The Relief Map of the Panama Canal at Jamestown.

The vertical scale was set at 1 = 333, a vertical exaggeration of six, after several scales had been tried and this had seemed to be the most effective and natural. In finishing the land surface, practically all of which on the Isthmus is covered with a very dense forest of low growth, the attempt was made to get a finish which would have the same appearance as the real country were the latter viewed from a balloon at a sufficient height to make it appear the same size as the map. This effect was obtained by beating the surface of the concrete after it had been floated and partly set, first with a board set with wooden knobs and then with a block of wood and an irregular surface covered with battered tin.

When the map was about half completed work was started on the concrete wall surrounding it. This wall showed 5½ ft above the sea level of the map on the inside and 2½ ft. above the surface of the walk on the outside; it was 12 in. thick and paneled on the outside. The panels were 16 in. high, about 5 ft. long and 2 in. deep, the moulding above the panels being 6 in. wide. By making the panels this length it was possible to divide the wall into 12 sections, exactly alike, and one set of forms was used for the entire work. The inside forms were in two pieces, one 12 ft and the other 18 ft. long, the full height of the wall, and were built of inch boards nailed to 2x4 in. verticals spaced about 2 ft. on centers. The outside forms were built in panels, one form for each panel, and were 2 ft. 9 in. high, the concrete being brought to the level of the bottom of the forms with slip boards. The forms were held in place by stakes at the bottom of the inside forms, through ties of telegraph wire at the bottom of the outside forms, and board ties about 6 in. above the top of the forms. The wall concrete was one part cement, three parts sand, six parts gravel, mixed wet. The forms were pulled the morning after a section of wall was finished, and the exposed surface plastered with a thin coat of one to two cement mortar brought to a floated finish. The top of the wall was given a granolithic finish.

When about half of the map and surrounding wall had been completed a start was made on the painting. The land surfaces were sized and painted one coat of flat green, shaded off dark and light to give the proper hill and valley effects, the rivers being lined out in light blue. The bottoms of the oceans and lakes were stained blue, with light blue shading close to the shore. The paint stood all right, except when put on cement not thoroughly dry, when the first rainstorm turned it light yellow.

Three concrete boxes were built outside the wall, 2 ft. 6 in. square in plan, with the top flush with the top of the walk around the map. A 1-in. iron pipe was connected with the water main and run into one of these which was located at the head of the Chagres River. This furnished the water supply to keep the lakes and oceans at the proper level, the water flowing down the Chagres, filling Lake Gatun and then overflowing into the Atlantic and through the canal into Sosa Lake and the Pacific. A 1-in. pipe under the locks permitted the draining of

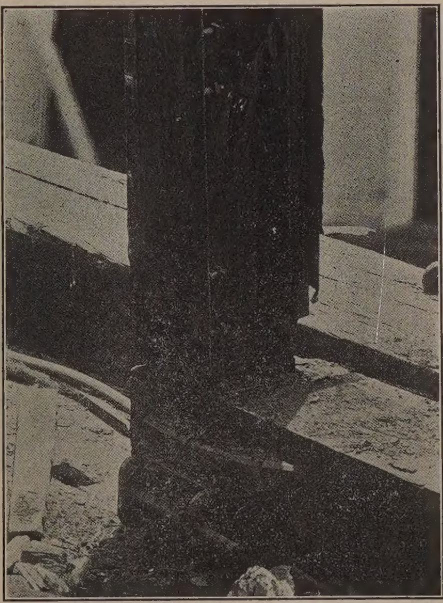
Lake Gatun, which, together with that of the other bodies of water, had to be done every fortnight. The outlet boxes for the Atlantic and Pacific were supplied with 6-in. earthenware drains connected with the sewer. The outlet was in the bottom of the concrete box and was stopped with a wooden plug sawed off at the desired water level and having a central hole, which took care of the overflow during rains. When it was necessary to drain the oceans the plugs were pulled, and when replaced were made tight by shaking sand around them.

The accompanying photograph gives a very good idea of the appearance of the finished map. The cost of construction was about $4,000.

A Bad Case of Rusty Steelwork.

A steel freight shed about 80 ft. wide, 200 ft. long and 22 ft. high to the eaves was built in 1878 at an Atlantic port and has since been exposed to salt atmosphere and moderately high wind. During recent construction operations, a portion of the framework was exposed and it was found that the feet of many of the columns were badly corroded, as indicated by the accompanying photograph of one of them, where the flanges broken away were merely kicked out by one of the laborers. At this point the thickness of the flange had been reduced from ⅜ in. originally to a minimum of ⅛ in., the remaining metal being soft and spongy. This extreme corrosion did not, however, exist to a very great height and was greatly diminished at a distance of 4 ft. above the base. A lighter had recently been in collision with one of these posts, which bent 3 or 4 ft. of it without breaking it, although its condition was the same as that of the one shown in the engraving.

The posts were only 8 in. wide and were braced merely with a 4-ft. kneebrace strut at the top. The cross-sections were built up with a single 8x¼-in. web plate and four 3x2½x⅜-in. angles, and if ever exposed to the assumed wind pressure of 20 lb. per square foot, must have sustained a high total stress. It is remarkable that the structure has so long served and is still in service and not very much distorted. It is evident that considerable water leaks through the eaves and, following the column to its base, collects there to a certain degree and exposes this part of the metal to excessive corrosion. Little or no evidence of proper painting or other care of the steel work could be observed.



Badly Corroded Foot of Wall Column.

Book Notes.

The interest shown in the public works of Frankfort, Germany, is so great that the city engineer, Herr Koelle, has prepared an excellent "Guide to Some of the Public Works" of that city. It is a handsome book of 79 pages, printed in English, French and German editions. The book takes up in turn the growth of the city and its extensions, the streets and roads, the street cleaning methods, the sewerage and sewage disposal, the water supply, the harbor works, the bridges, and the systems followed in laying out new parts of the city. A large number of excellent illustrations are provided and the salient features of each subject are stated concisely so that the visitor can readily grasp them.

In view of the rapidly growing use of hollow concrete blocks as a building material the publication of a thoughtful paper by Mr. E. S. Larned, entitled "Regulation and Control of Concrete Construction," is decidedly timely. The author points out at the outset that while cement is a very important element of concrete work of any sort, nevertheless the other materials with which it is combined and the manner of mixing and placing those materials and the forms to contain them are also of prime importance, and should be submitted to the same inspection and study by competent persons as are usually required of the cement. This is not so well appreciated by architects and builders who use concrete blocks as is desirable. In order to afford a basis for discussion of the subject Mr. Larned then outlines a set of specifications for the materials for such blocks and the methods of mixing, moulding and curing them. The paper has been printed for free distribution by the Association of American Portland Cement Manufacturers, Land Title Building, Philadelphia, and deserves a wide circulation.

In these days of widespread concrete construction for works formerly executed in brick or stone masonry, there is some danger of overlooking the many merits of these latter materials. Attention may well be called, therefore, to an excellent pocketbook of rules, directions and tables, bearing the title of "The Building Mechanics' Ready Reference." The author is Mr. H. G. Richey, a superintendent of construction of United States public buildings. The volume explains the different classes of masonry, the methods of carrying on work and of estimating quantities, various practical features useful to masons, gives numerous tables of the properties of building stones and other materials employed in connection with them, and furnishes a large variety of tables useful in connection with masonry construction. The author's long experience in supervising the erection of different grades of buildings for the federal government has naturally made him familiar with masonry work in many parts of the country, and many of the hints he gives are likely to be of interest to those who consider themselves in complete touch with all that is known in one section, but have not become familiar with the way work is done in other parts of the country. Special mention should be made of the excellent character of the illustrations, which are well chosen to make clear many things connected with masonry and the methods of constructing it which cannot be explained in words. (New York, John Wiley & Sons, $1.50.)

A useful handbook on the principles and methods of warming buildings has been prepared under the title of "Principles of Heating," by Mr. Wm. G. Snow. The book is apparently intended for the use of steam fitters and others who wish to have a practical guide to the design of satisfactory installations, and is not an elaborate theoretical treatise. The heating power of fuels and the construction boilers and heaters are taken up in the first chapter. In the second chapter the use of gas, oil and electricity for heating is discussed. The third chapter goes into the details of the capacity and fuel consumption of heating boilers and describes methods of testing furnaces. The next three chapters are devoted to a consideration of the phenomena that take place in heating and cooling air and in warming by direct radiators, and to the computation of radiation for direct warming and for use with blower systems. Information is also given concerning the methods of heating water and computing the size of coils for the purpose. The ninth chapter is a discussion of the flow of steam in pipes, the methods of computing the sizes of steam mains for different systems of heating, the selection of exhaust pipe sizes and the effect of back pressure on engines. The next chapter is an explanation of the methods of designing hot water mains, while the last chapter is devoted to vacuum and vapor systems of heating. On account of the interest now shown in such systems, the space devoted to them is considerable and probably more information is given regarding such methods of warming than is available in any other single book. Throughout the volume the author has laid special stress on the application of the heat-unit method of design. (New York, David Williams Co., $2.00.)

A "Hand-Book of Steel Reinforcement" has recently been prepared by the engineers connected with the American Steel & Wire Co. It opens with an explanation of the position which concrete now holds among engineering materials and then takes up the use and properties of reinforced concrete. Afterwards the cost of the material is discussed and there are chapters on the strength of concrete, steel for reinforcing, the protection of metal imbedded in concrete, fire protection, the modulus of elasticity and other properties of concrete, the methods of bonding old and new concrete, the effect of freezing and methods of finishing the surfaces of concrete. These chapters are mainly derived from various standard works. They are followed by tables of the weights, areas, sizes and other features of triangular and square mesh reinforcements, a specialty the company is now pushing and the advertisement of which in a mild way is evidently the main purpose of the book. These tables are followed by others giving the safe bending moments, weights and thicknesses of slabs and panels, with diagrams of the same data for the benefit of those who prefer to work from them. The manner in which the tables are prepared is explained at length and information is given concerning the various sizes of wire that can be used in slabs. The tables are based on a working stress of 16,000 lb. per square inch in steel, and a 1: 2½: 5 Portland cement concrete. The book does not take up the design of columns, beams or girders. (Chicago, American Steel & Wire Co., $2.00.)

The last number of the "Mitteilungen ueber Forschungs arbeiten," published by the Society of German Engineers is a monograph by Dr. R. Biel on the nature of the operation of centrifugal pumps and ventilators, "die Wirkungsweise der Kreiselpumpen und Ventilatoren." It is the author's belief that satisfactory information concerning these principles can be derived only from a study of experimental data, from which general laws can be deduced. Accordingly he opens this monograph with a statement of what has been done in the subject heretofore and an explanation of the theoretical fundamentals, after which he takes up in detail a series of experiments with machinery of this class. Complete data are given regarding these trials and they are followed by a series of discussions concerning the important facts indicated by the test results. The monograph is published at 1 mark by Julius Springer, Berlin, who also publishes at the same price the author's thesis submitted for the degree of Doctor of Engineering at the technical academy at Charlottenburg. This is a remarkably interesting discussion of the loss of head attending the flow of liquid and gaseous fluids, "Ueber den Druckhöpenverlust bei der Fortleitung tropfbarer und gasförmiger Flussigkeiten." The first part of the thesis is a discussion of the critical points at which the curves of loss of head are interrupted, and the second part is an investigation of the loss of head in pipes when the velocity exceeds the upper critical point. This investigation leads the author to suggest a new formula for the loss of head, $h = LR\ (av^2 + bv)$, where h is the loss of head, R is the hydraulic radius, v the velocity and a and b are coefficients selected from diagrams based on experimental results which are tabulated for ready comparison. The third and final section of the thesis is a discussion of the application of the formula to open channels and streams.

Letters to the Editor.

Lattice Bars.

Sir: Mr. Horace E. Horton in a letter regarding "Lattice Bars in the Quebec Bridge," which appeared in your issue of Sept. 28, states, "The relation of lattice to the member is not specified anywhere in any general specification. That the individual lattice with its rivets should have some relation to the stress of the member surely appeals to us as reasonable since the failure of the Quebec Bridge, and yet no one has ever put in print anything that has come to my notice on the subject."

In an article on wrought iron columns, published in the "Lehigh Quarterly," June, 1891, the writer made a suggestion which he shortly afterwards incorporated as a clause in the New Jersey Steel & Iron Co. specifications as follows: "The lattice bars shall be so spaced that each channel between lattice connections shall be stronger than the column considered as a whole, and their size shall not be less than would be obtained by treating the column as a lattice girder supported at the ends and loaded at the middle with a load equal to 3 per cent. of the total compression on the column."

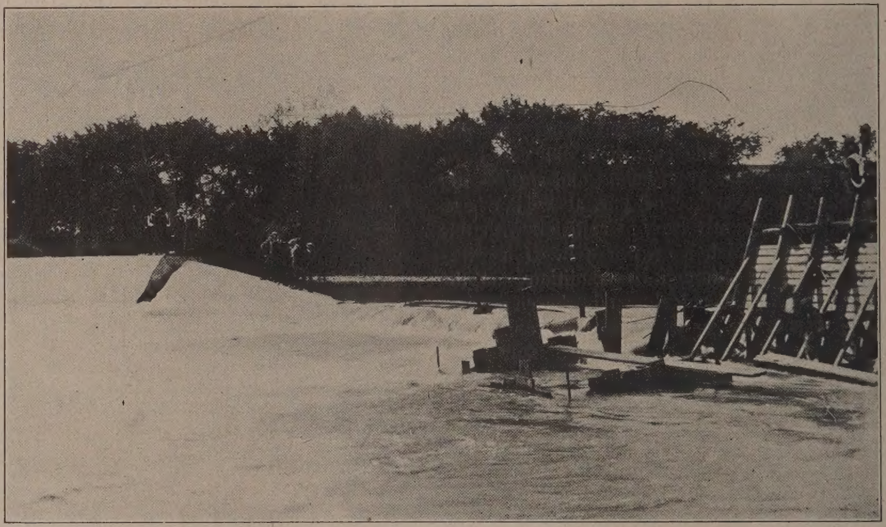
Henry S. Prichard.

Beaver, Pa., Oct. 4.

An Undermined Dam.

Sir: In your issue of November 24, 1906, there was a letter by the writer illustrating a reinforced concrete dam of original design which was being built at Dayton, O. The method of construction and a typical cross-section of the dam were there shown. At that time the dam was completed to within about 50 ft. of the end. The part left open was a deep channel, with a gravel bed. A large valve had been built into the completed part near the end, the intention being to pass the normal flow of the river through this while closing the end. The whole uncompleted end was then enclosed with a cofferdam, the top of which was several feet below the crest of the dam. The cofferdam was completed and the work progressing nicely, the water meanwhile flowing through the valve, when a sudden flood overtopped the cofferdam and undermined the end of the completed structure, which rested only on gravel. As a result about 25 ft. of the dam broke off and gradually dropped perpendicularly, thus remaining in line with the rest of structure. The broken piece contained the valve, and this had not been damaged. High water continuing, the work was temporarily abandoned, with the intention of resuming it this last spring. Litigation put off the renewal of the work until this fall, and it was then decided to leave the sunken piece in the river bed and build over it.

Instead of now constructing a cofferdam enclosing the whole of the open end and high enough to cause all flood water to flow over the crest of the dam, only the abutment end was enclosed, leaving an open gap of about 6 ft. between the cofferdam and the sunken part, the top of which was now slightly below water and about 7 ft. below the crest of dam. Into this abutment end a new valve was to be built, and then the gap was to be enclosed and filled in, thus completing the dam. Work was proceeding slowly when another flood came, and the water in its mad rush about the ends of the submerged part undermined some more of the dam, and a piece about 20 ft. long broke off, as shown in the accompanying photograph. The submerged end has fallen upstream, is badly out of line, and work is again at a standstill. The part submerged is the first piece that broke off, and the water is here over 20 ft. deep and getting deeper. Upstream a short distance the water is comparatively shallow.



An Undermined Dam at Dayton.

If the dam had been commenced from the end that is now being put in very little trouble would have been experienced, for the river is very shallow on the completed side of dam. If the first flood had not occurred the dam would have been completed in about two weeks, but it seems that the contractors were taking chances on floods, with the present results. A small additional cost would have built a cofferdam of sufficient height to have avoided the first break, with its costly after results. Yours truly.

Dayton, Sept. 30. Edward Balbach.

Wire Rope for Concrete Reinforcement.

Sir: Referring to the description of the reinforced concrete reservoir appearing on page 312 of your issue of Sept. 21, 1907, is not the use of steel cables for reinforcement very bad practice, on account of the permanent and material increase in length and decrease in diameter which takes place in steel ropes subjected to high tension? While he knows of no tests of the kind, the writer would expect to see concrete beams reinforced by wire ropes fail under loads which such beams would carry with safety if ropes were replaced by steel rods of corresponding number and diameter, especially so, if the ropes were new and did not have most of the stretch taken out of them by repeated high stresses.

Possibly second-hand wire ropes long in use under heavy loads would not be subject to further material increase in length and decrease in diameter, but surely the theories of reinforced concrete design are quite complicated enough without introducing and adding the stretch of a wire rope to the uncertain ratio of elasticity existing between steel and concrete.

In the design in question the steel cables are apparently stressed about 20,000 lb. per square inch, neglecting all tensile strength in concrete. This is a pull quite sufficient to produce a material stretch in a new wire rope, quite apart from the elasticity of the metal therein. In defence of the design in question, it may be said that there is no beam action and that the total stretch of the cable will be so uniformly distributed that there will be no visible resulting cracks in the concrete. We are not at all certain that the last assumption about the stretch is true. Quite generally, we think, it would not be true. Messrs. Westinghouse, Church, Kerr & Co. are such an able and reputable engineering firm that one is led to anticipate that there were some exceptional conditions justifying the design in question. Any general use of wire ropes in reinforced concrete would certainly result in many failures. Moreover, the item of cost is entirely against it. Yours truly,

J. L. Campbell.

El Paso, Tex., Sept. 29.

Cost of Riveting.

Sir: The cost of machine riveting is hard to get at, as so many conditions enter. Generally speaking, however, as a machine will drive rivets as fast as they are fed to it, the chief cost is that of handling the work. This varies with the class of work, heavy and bulky work being, of course, harder to handle. Assuming $4.50 a day for the labor (exclusive of heater), if a machine drives some 700 or 800 rivets per day, the cost for labor, power and general charges will be from ⅝ to ¾ cents per rivet.

Pneumatic hammer rivets in ordinary shop work will cost hardly less than 1½ cents per rivet for similar charges. To be very conservative assuming only ½ cent saved per rivet, there is $1,000 or $1,200 saved per year. As a matter of fact, much larger returns generally result, for, if you double the machine rivets driven per day, the cost per rivet is practically cut in half and the savings are enormous.

This comparison applies only to an air machine, which, for 2,500 rivets, takes about the same amount of air as one pneumatic hammer. For hydraulic driven rivets several hundred dollars additional must be allowed per year for power.

Chester B. Albree Iron Works Co.

Allegheny, Oct. 2.